S. A. E. JOURNAL

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W. G. WALL, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

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Program Proves of Exceptional Interest

Over 1000 Attend S. A. E. Annual Meeting in Detroit, Jan. 24 to 27, at Book-Cadillac

Without doubt many factors are responsible for the record-breaking attendance at the Annual Meeting. The total attendance of more than 1000, with a session attendance averaging almost 300, exceeds that of any Annual Meeting held in the past. An exceptional program, the fact that this was the first Annual Meeting of the Society held in nearly ideal surroundings for social contact, the increased interest in the activities of the Detroit Section, and other factors undoubtedly accounted for the new standard of attendance established.

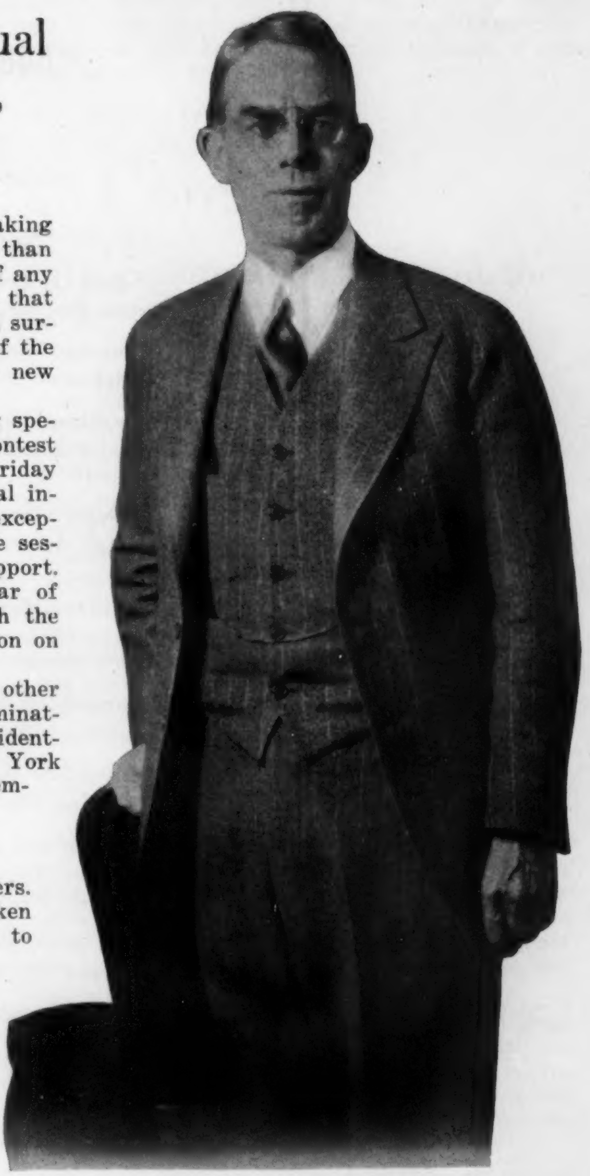
It would be difficult to point out any papers or sessions meriting special mention above the others. Beginning with the Stock-Car-Contest Symposium, Tuesday afternoon, and closing with the Body Session, Friday evening, the program was replete with engineering features of vital interest to the members. Great credit is due the authors for the exceptional papers presented, to the chairmen for the way in which the sessions were conducted, and to the members for their interest and support.

The Annual Meeting brought to a close the administrative year of 1927 under the presidency of John H. Hunt. In accordance with the usual custom, President Hunt took the chair at the Business Session on Tuesday evening.

Following the acceptance of the reports of the Administrative and other Committees and the election of three members-at-large for the Nominating Committee, President Hunt introduced Col. W. G. Wall as President-Elect, announcement of his election having been made in New York City at the Annual Dinner. President-Elect Wall addressed the members in part as follows:

Remarks by President-Elect Wall

"As a scientific body we are naturally interested in scientific matters. We realize that a great many things in life which have been taken simply on faith have been proved recently. It is a great relief to the average mind to turn to those things which can be easily proved.



President William G. Wall

"Science provides facts which we can readily grasp and comprehend and which, fortunately, do not depend directly upon human frailties.

"We of the present generation have a great advantage over our forefathers in that, although the things we call scientific facts have always existed, it has been only in the last few centuries that most of them have been discovered. With the exception of a few of the most fundamental matters regarding astronomy, geography and mechanics, and possibly primitive medicine, most of these

THE ANNUAL MEETING NEWS ACCOUNT

Meetings Calendar

Summer Meeting
June 26 to 29, 1928
Chateau Frontenac, Quebec

Sections Calendar

Buffalo Section Meeting—Feb. 7, 1928
Starters for Aircraft Engines—Raymond P. Lansing

Chicago Section Meeting—Feb. 14, 1928
New Developments in Automotive Design—Prof. D. A. Fales

Cleveland Section Meeting—Feb. 13, 1928
Generation of Electric Current for Automotive Apparatus—
B. M. Leece

Detroit Section Meeting—Feb. 13, 1928
Production of Automobile Frames by Automatic Machinery—
John P. Kelley

Indiana Section Meeting—Feb. 9, 1928
General Progress Meeting with reviews of the recent automobile shows and a general discussion under the direction of F. F. Chandler

Metropolitan Section Meeting—Feb. 16, 1928
Specialized Service—Speakers to be announced

Milwaukee Section Meeting—Feb. 1, 1928
Military Motor Transport—W. T. Rockwell

New England Section Meeting—Feb. 8, 1928
Brake Testing and Recent Brake Developments—A. Vance Howe, F. W. Parks and Charles F. Smith

Pennsylvania Section Meeting—Feb. 14, 1928
Generators and Motors for Gas-Electric Drive—C. A. Atwell

Southern California Section Meeting—Feb. 10, 1928
Brakes, Brake Wear, Brake Adjustment, and Brake Testing—
J. E. Van Sant, John H. Watrous and other speakers

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discoveries have been made in the last 200 years, and a great preponderance of them in the last 50 years.

"We ask why this great progress has been made in recent times. Most of you will answer that 'It is a case of education,' or 'It is our system of publicity,' or 'One fact is established and hundreds spring from it.'

"One of the best illustrations I know of why this great progress has been made in recent times is this Annual Meeting of ours. It brings us together, and in place of keeping to ourselves all the things that we learn as was customary a few years ago, we discuss them freely with one another, and by so doing we present them to the world. In the end we are better off and we have made very much greater progress than we would otherwise.

"Nothing stimulates the mind like contact with other minds, and so this 4-day meeting of ours should not only be interesting and instructive, but, I am quite sure, will be productive of many new ideas.

"In regard to our policies, I think the best thing we can do is to carry on where the present administration is leaving off, for President Hunt has certainly made a great success this year and I think that if the incoming administration does as well both the officers and the Society at large will be very thankful."

The Annual Meeting was held on the ballroom floor of the Book-Cadillac. The sessions were in the Crystal Room, entrance being through the Italian Garden, which was used as an assembly room for engineering and social discussions, for exhibits and for the buffet suppers that were served following the evening sessions, a new feature for S. A. E. Annual Meetings. Committee meetings were held in private dining rooms adjoining the Crystal Room and the Italian Garden, the connecting foyer being used for registration and for the headquarters of Nathan Lazarnick, whose photographs are a most important feature of the Annual Meeting news account.

Debate on Stock-Car Contests

To Race or Not to Race Is Made the Subject of a Spirited Discussion at the Opening Annual-Meeting Session

Numerous opinions both for and against the continuance of stock-car racing-contests were expressed by representative speakers at the opening session of the Annual Meeting held in the crystal room of the Book-Cadillac Hotel, Detroit, on Tuesday afternoon, Jan. 24. The most important feature of the discussion related to the intrinsic value of preparing for and participating in the stock-car races on the part of the car builders. A. W. S. Herrington was chairman and, in his opening remarks, he called attention to the three factors which the subject involves: first, whether stock-car racing is or is not a good thing for the industry; second, the control of racing, if it be held, which lies within the province of the American Automobile Association; and third, the value of stock-car racing in furthering the development of the car from an engineering viewpoint, the last being a factor in which the Society is interested primarily.

Technical and Ethical Aspects

In discussing some of the technical and ethical aspects of stock-car racing and tests, Paul Dumas, of the Chilton Class Journal Co., whose paper on the subject was read by L. C. Dibble of the same company, reviewed the recent history of stock-car racing and outlined its present status. He stated the points that are held to be advantageous by those who believe that stock-car racing is beneficial, and arrayed against them the arguments advanced by those who are opposed to it. With respect to what constitutes a "stock car," Mr. Dumas said that it is believed the existing definition as contained in the booklet on Stock-Car Tests issued by the American Automobile Association and in the supplementary regulations as contained in stock-car-event entry-blanks now being issued is adequate if adhered to in both letter and spirit. He suggested, however, that the Stock-Car Contest Advisory Technical Committee of the Society and the Contest Board of the American Automobile Association be polled and a vote taken on the following specific propositions affecting stock-car status, regardless of whether the vehicle is being contested in a competitive race or a certified test, and that these propositions be supplementary to the agreed general definition of a stock car.

(1) Based on the assumption that a fully equipped car run on an approved track offers less potential danger to the driver and other contestants than a similar car driven on the highway at similar speeds, shall or shall not the running-boards, side and front aprons, windshield assemblies, lamps, top, spare equipment, and mud guards and extending brackets, be removed from vehicles contested as "stock cars" in competitive events and certified tests?

(2) If it is the consensus of opinion that the foregoing appendages may be removed, shall it be permissible or shall it not to install a sub-windshield or windbreak of some standard specification on contested cars?

(3) What permissible machining tolerances on the camshaft cams, expressed in degrees of crank-shaft rotation, shall be allowed in the valve-timing specifications of contesting stock-cars?

(4) Since wear incurred in a long-distance test or race may affect the valve-timing specifications, shall the appointed technical committee be compelled to examine each contesting car before the start of the test or contest?

(5) In checking the compression ratio of an engine, shall the compression ratio be assumed as the average ratio of all cylinders or shall the average computed after checking any two cylinders be considered the compression ratio of the engine?

(6) What variations or tolerances from the compression ratio indicated in official classifications, or found on a similar model chosen for checking purposes, shall be permissible; these tolerances to be expressed in percentage of the combustion-chamber volume?

(7) What, if any, shall constitute the regulation method for determining the mechanical compression-ratio of an engine?

(8) Since it is generally agreed that the all-round 100-per-cent-efficient spark-plug has not yet been discovered, shall it or shall it not be permissible to install spark-plugs of other than the identical model and make supplied as regular equipment on the car as shipped to domestic dealers?

(9) What permissible variations, as expressed in pounds of tension at any given length, shall be

allowable on valve springs tested after the completion of the event?

(10) What procedure should be followed to determine that the tire equipment used on a contesting car is strictly "stock" equipment?

(11) Where parts, equipment, or specifications classed as "optional," are utilized on a contesting car, what evidence should be required to determine whether the use of such optional equipment is bona fide or an attempt at evasion?

(12) If, in the opinion of the technical committee, there is reason to doubt the bona-fide status of the optional equipment mentioned in item (11), shall the technical committee be empowered to disqualify such contestant or bar the use of such equipment or specifications when it is found that the same are not available in reasonable quantities from the stock of the distributor or car builder's parts-department?

With regard to the control of post-event advertising, Mr. Dumas stated the two following propositions: (*a*) in any type of stock-car sanctioned-event where a contesting vehicle has made use of a bona fide optional part, assembly or specification, shall it or shall it not be compulsory that the post-event advertising-copy state plainly which ones of the offered options was utilized in the particular event; and (*b*) since the control of stock-car-event advertising-copy has technical as well as ethical aspects, shall or shall not such advertising copy be submitted for approval to the advisory technical committee of the Society or to the technical committee functioning at the event, coincident with its censorship by the contest board of the American Automobile Association?

Engineering Advantages of Racing Stressed

F. E. Moskovics, of the Stutz Motor Car Co., stated that he is a firm believer in stock-car racing from the viewpoint of the engineering or technical advantages to be gained thereby. He cited an instance in which two of the bearings in the engine burned out regularly after long operation, these two being lubricated from a common oil-groove which racing conditions demonstrated was too small, and said that the trouble was eliminated by making this groove larger. He said that his company has learned an engineering lesson from each race in which it has competed, a lesson that was reflected as soon as possible in the every-day production of the car. He maintained that there is a vast difference between competitive racing and privately conducted trials or tests, in that racing imposes conditions and entails risks that do not pertain under ordinary conditions of test, thereby developing troubles that cannot be ascertained in any other way.

Benefits to Car Builder and Public

H. C. Snow, of the Auburn Automobile Co., said in part that the automobile-purchasing public requires the backing-up of performance claims with a stronger guarantee than the mere statements of performance that are made by those who build and sell cars; therefore, there is a need for certified tests conducted under uniform rules by a neutral body. While maximum speed is the determining factor in a stock-car race, it is not speed in itself which has the greatest value so much as it is the other characteristics which speed indicates. Stock-car racing-contests are beneficial to a car builder in that they provide a means of demonstrating to the public the unquestionable performance-characteristics of his cars as compared with the cars of other builders.

It is important that there be a very definite understanding as to what a stock car is, said Mr. Snow. When its qualifications have been determined, they should not be altered during the season since this will give a builder who wishes to compete in the contests an opportunity to design and equip his cars so as to meet all the requirements as a stock car. To make stock-car racing of the greatest interest to the public, the cars competing should be the same as those sold by the dealers. The tests will then determine precisely what can be expected in the way of performance of the cars the public may buy. The speaker then went on to state details of desirable practice in selecting cars for contests, equipping them, and regulating the events.

Difficulty of Defining a Stock Car

Mentioning that all the early cars were demonstrated to the public on the race-track, T. J. Lítle, Jr., of the Marmon Motor Car Co., said further that those were the days when the automobile was a luxury and when these racing demonstrations appealed to the sporting instincts of the wealthy. But in his opinion it seems that today we do not need this type of publicity, although it has been used very successfully in some cases.

With regard to the great difficulty of adequately defining and branding a stock car, Mr. Lítle said that he has been openly opposed to the present methods of officially approving the stock-car entries. He holds that the stock car should be picked from a showroom floor, preferably by a representative of the American Automobile Association, and that the car should be kept in custody up to the time of the race; but that, during this interim, the contestant should be allowed to run the car in up to possibly a distance of 1000 miles, and also should be allowed to refit the car with a high-speed axle provided that such an axle actually is optional and in production and is sold in some considerable quantity. In other words, he believes that the public should be assured beyond question of any doubt that the cars entered in a contest really are stock cars. Mr. Lítle said that he does not wish it understood that he is opposed to stock-car racing; but he does wish it to be thoroughly understood that, in his opinion, it is difficult and dangerous to permit racing of this sort unless adequate supervision is provided, which he said will prove to be much more costly than is generally imagined.

Stock-Car Racing Expensive

It was said by James Crawford, of the Chevrolet Motor Co., that racing is the most expensive form of determining the engineering characteristics of a car. He cited an instance in which about $4,000 was spent and several engines were wrecked in an attempt to put a car in racing condition, and in which the total cost of the same finding at the factory was about $225. In his opinion, the greatest harm that is done by stock-car contests, from an engineering viewpoint, is the fact that they draw the engineer's attention away from the duties he has at the factory and consume too much of his time in traveling and in attending the contests. Further, he said that high speed is a very unfair criterion upon which to judge a car's value. Very few racing drivers and very few people desirous of high speed buy automobiles. What the public wants is riding-quality and the like. For this reason, Mr. Crawford believes that there is but little advertising value in racing contests, other reasons being that there always will be progress in development, that no matter how good a record a car may have today some other car will beat the record tomorrow, and that the general public is exceedingly forgetful of details as to what car may have won and why.

Difficulties Faced by the Contest Board

One of the difficulties experienced in the administration of the Contest Board of the American Automobile Association, said David Beecroft of the Chilton Class Journal Co., is that its members reside in widely separated parts of the Country and it is therefore seldom feasible to convene the membership on short notice. If there is to be a ruling as to stock cars in America, the ruling should, in Mr. Beecroft's opinion, harmonize to some extent with the conception held in England, France, Germany and other automobile-producing countries, as to what constitutes a stock car, because 8 to 10 per cent of the automobile production is being exported at

present and it is but natural that the car builders will advertise the performances over the entire world. He stated that we have in this Country one conception of what a stock car is and of what stock-car rules should consist, and that Europeans have an entirely different conception of these matters. The American method is to select a car that is exactly the same as those sold and then to allow certain changes to be made. In Europe, a few broad restrictions are imposed and the builder is then allowed to develop wide deviations from stock-car practices. With regard to difficulties incident to the control of advertising that results from stock-car contests, Mr. Beecroft said that it will be hard to overcome them but that, if stock-car contests are to be continued, the situation with regard to advertising must in some manner be clarified.

Great interest was manifested by the audience of nearly 150 members and guests while the foregoing opinions were being expressed, and this interest was continued throughout

CELEBRITIES AT THE STOCK-CAR CONTEST SYMPOSIUM

A. W. Herrington (Center), Who Wielded the Gavel at the Symposium; H. C. Snow (Upper Left), of the Auburn Automobile Co.; F. E. Moskovics (Upper Center), of the Stutz Motor Car Co.; T. J. Litle, Jr. (Upper Right), of the Marmon Motor Car Co., and James Crawford (Lower Right), of the Chevrolet Motor Co., Who Submitted Prepared Discussion for and against Stock-Car Contests; David Beecroft (Lower Center), a Member of the Contest Board of the American Automobile Association; and Norman G. Shidle (Lower Left), of the Chilton Class Journal Co., Who Took Part in the Discussion

the general discussion which followed. Among the additional opinions expressed, the belief was stated that there is much to be gained from the trial type of competition but that much of such information can be gathered without going into that kind of contest. One speaker said that he fails to see wherein stock-car racing will be of any great benefit unless there is evidence from the public of intense interest in it, which interest, the speaker remarked, he has thus far failed to detect. The Indianapolis Speedway was mentioned by one prominent member as having been a great school at which engineers and car builders who have raced their products there have found out things of engineering value which they could have ascertained in no other way. Another prominent speaker remarked that practically all American cars are designed against a budget; that is, a certain amount is devoted to the production of that car. Out of that sum it is desired to give the average owner everything that can be given him and for this reason every car today carries on it certain equipment that makes things somewhat easier for the advertising department of the company, although, from an engineering viewpoint, a slightly different weighting of the labor and material might have been made.

During the session Chairman Herrington announced that members interested in racing would have an opportunity at the close of the session of seeing photographs of the car developed by Mr. Moskovics' company to bring back to the United States the automobile speed-record, Mr. Moskovics having brought photographs of the car with him. Some of these are reproduced elsewhere in this issue. The present record is 203.79 m.p.h., made by Major Segrave in a Sunbeam car.

Aviation in Its Broad Aspects

Numerous Phases of International Commercial Flying in the Western Hemisphere Considered

Features of the session devoted to international flying, held Tuesday evening, Jan. 24, included the presentation of four papers, the showing of motion pictures of scenes in Quebec, Canada, where the 1928 Semi-Annual Meeting is to be held, and motion pictures of the chassis-assembling contest between Section teams that was held at French Lick Springs, Ind., while the 1927 Semi-Annual Meeting was in progress. Hon. William P. MacCracken, Jr., assistant secretary of commerce for aeronautics, was represented by Col. Harry H. Blee, senior business specialist in the aeronautic branch of the Department of Commerce, who outlined the possibilities of commercial flying within the territory of the Americas. Hon. Edward P. Warner, assistant secretary of the navy for aeronautics, was present and spoke on the flight possibilities over the Caribbean Sea, the Gulf of Mexico and in the vicinity of the West Indies. Major Herbert A. Dargue, of the Air Service, delivered an interesting and entertaining address on the conditions that must be met for successful air-transport in Central America and in South America; and J. A. Wilson, comptroller of civil aviation for the Royal Canadian Air Force, read his paper on International Flying between the United States and Canada.

Following the adjournment of the technical session, a most enjoyable buffet supper was served in a spacious parlor of the hotel which was adjacent to the meeting room, and the members and guests in attendance at the meeting, more than 300 in number, were thus afforded an opportunity for refreshment and social intercourse, of which they were evidently glad to avail themselves.

General Western-Hemisphere Conditions

Colonel Blee said in part that conditions in the Western Hemisphere are, in general, favorable for successful air-transport service. The topography of the continents, with their valleys and rivers and their mountain ranges extending in a general northerly and southerly direction paralleling the coast lines and cut by numerous passes, facilitates aerial operations in most of the countries. The distances between centers of population are great and are broken by relatively few international boundaries.

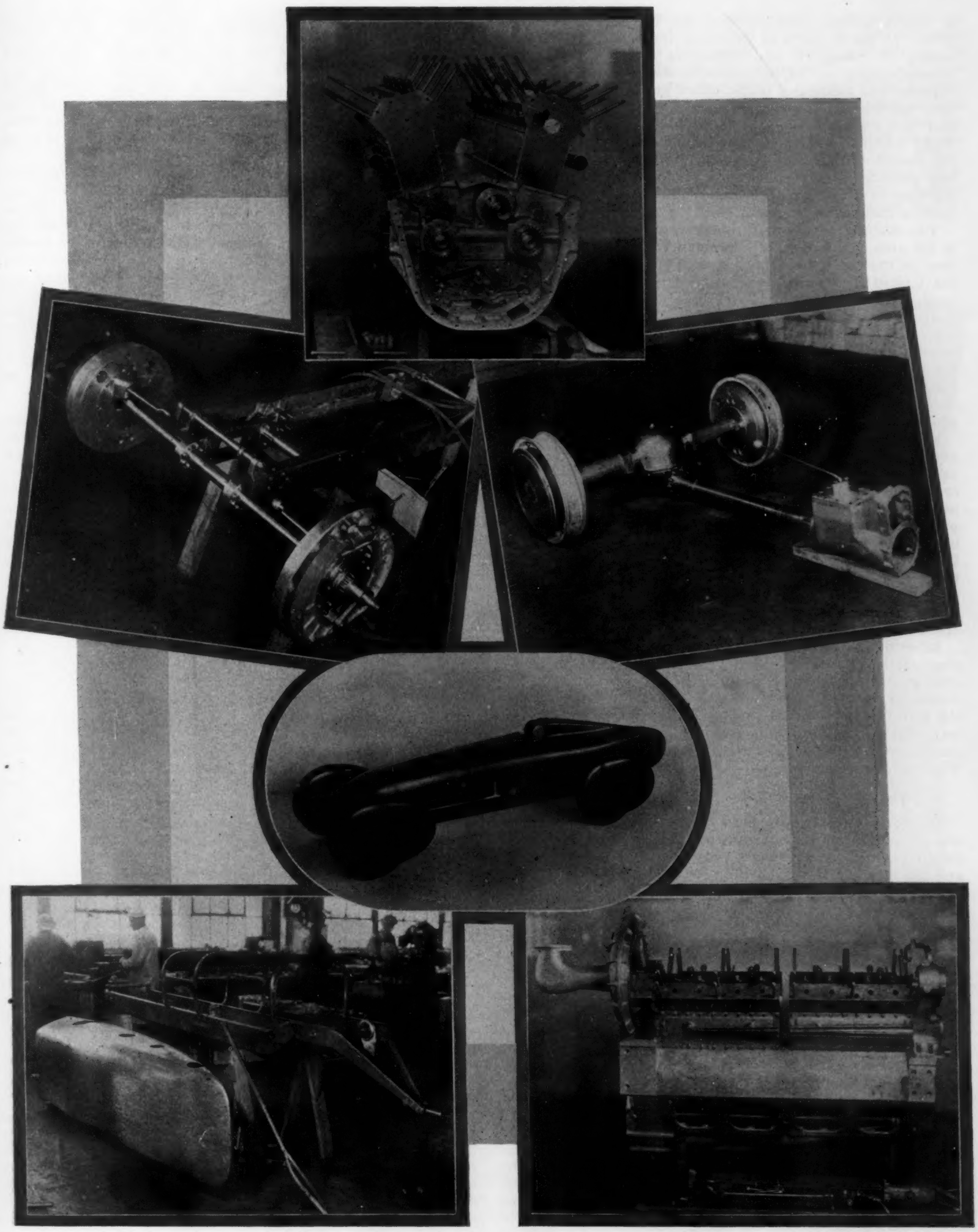
In the United States, the air-transport lines operate on a strictly commercial basis and without subsidy. They are speeding up business throughout the Country and are proving to the public mind the practicability of air transportation, as well as demonstrating that air transport can be operated at a profit. In the light of these operations, there is every reason to believe that air lines operated internationally throughout the Western Hemisphere should meet with success, especially when it is remembered that in many of the countries the ordinary transportation systems are not as highly developed or as extensive as those in the United States.

The speaker said that the success of air transport depends primarily upon the service it can render in comparison with that rendered by the existing means of transportation. The air line must show a definite advantage, such as greater speed, better travel-connections, greater comfort and convenience, or a more scenic and more enjoyable mode of travel, if it is to attract business. At the same time it must meet the public demand for safety and reliability, and the charges made must be economical from the viewpoint of the excellence of the service rendered. In order that air transport may meet these requirements, it is necessary that the aircraft be operated over definite routes, on regular schedule, both day and night and through all kinds of weather. To this end the Government of the United States, through the medium of the Department of Commerce, is establishing a system of national airways extending from coast to coast and from the Great Lakes to the Gulf of Mexico.

Colonel Blee said that he believes the time is not far distant when a network of airways will extend through the Americas and when the countries of the Western Hemisphere will be linked together by a system of highly developed and highly efficient commercial air-lines that will speed up commerce and industry and bring the countries close together in better understanding. Further, that international flying in the Western Hemisphere will extend across the seas to the Eastern Hemisphere and it is likely to include the operation of airplanes in connection with high-speed ocean liners; transoceanic airship lines operating very large, commodious, elegantly appointed rigid airships; and, later, transoceanic airplane service, which probably will utilize large flying-boats operating over routes selected so as to permit of at least one intermediate stop for taking on fuel and supplies.

Flight Over the Caribbean Sea

The requirements for successful air-transport within the area comprising the Caribbean Sea and the West Indies present problems very different from those pertaining to successful commercial flight in the United States and in Canada, said Secretary Warner. A distinctive topography characterizes the Central American peninsula and the West Indian Islands. The climate is different and the vegetation



Will It Establish a New World's Record?

Photographs of the Model and the Major Units of the Car Being Built by F. E. Moskovics To Break the World's Record of 203.79 M.P.H. Established by Major H. O. D. Segrave

is totally unlike anything that the United States has to offer. In many parts of this area there is a deficiency of means of transport, and difficulties exist in the way of transportation and of the intensive development of freight, express, and passenger traffic which are unfamiliar to those who provide air-transport facilities in the United States and in Canada. Hence it is probable that international flight which originates in the United States and continues southward will prove to be wholly different from that which has provided flight experience in this Country, and the drawing of direct parallels and analogies is likely to prove itself a dangerous process.

Two distinct functions for commercial air-transport exist in the area in question, in Secretary Warner's opinion. The first is that of establishing a general connection between the United States and the southern portions of the Caribbean Sea, particularly to the Canal Zone. The second is distinct from the mere crossing of the Caribbean Sea to some point in Central America; it has to do with the provision of both international and internal transportation in the countries surrounding the Caribbean Sea. These services naturally go together and cannot be separated entirely; yet, from the technical viewpoint, they constitute problems which are distinct to a considerable degree.

Secretary Warner went on to discuss the feasible routes and to comment upon the differences in the requirements to be met according to whether the routes lie over the land or over the sea, with reference also to the types of aircraft needed. To him, the flight problem of the Caribbean seems primarily a task for the seaplane. But before investors can become deeply interested in promoting air lines in the Caribbean area a seaplane industry must be created, a sympathetic attitude must be maintained by the Government, it must be shown that traffic exists to warrant international air-lines, and data must be obtained on the conditions of operation that are likely to be encountered.

After giving some details regarding the great savings in time made possible by flight within the area considered, compared with the time required when using the ordinary means of transport, Secretary Warner discussed some of the purely international and political aspects of the subject, stating the need that provision be made for the free passage of commercial aircraft between the countries of the Western Hemisphere.

Flight in Central and South America

Saying that the 1926 Good-Will Pan-American Flight presented unparalleled opportunities for securing first-hand data regarding air-transport possibilities in Latin-America and for demonstrating the feasibility of air routes there which will expedite commerce and bind the nations of the Western Hemisphere with closer bonds of friendship, Major Dargue, who commanded this flight, a journey of more than 22,000 miles, described the route followed and then discussed the practicability of air routes southward from the United States. Two natural lanes present themselves: one is by way of Texas and the other is through Florida.

Major Dargue said that the Gulf Coast of Mexico is generally a sandy beach with stretches of lowlands adjacent thereto. The interior is a rough country, and the greater part of the civilization is found in the eastern portion. The Isthmus of Tehuantepec is narrow, and a 3000-ft. altitude will clear all the mountains. In Central America the predominating characteristic is the range of mountains, largely volcanic, which run lengthwise through the several republics. The Pacific Coast is generally rough and rugged, but great stretches of lowlands exist on the Caribbean side. Most parts are sparsely settled and the jungle is extensive. Commercial activities center largely in the capital cities and the few seaports. In his belief, a capital-city air-route should attract commercial enterprise, but an air-route down the East coast of Central America does not, to his mind, offer the same prospects of success as does the capital-city airway.

As to the Florida route, this is from Key West to Havana and thence either to Yucatan and Central America or throughout the length of the West Indies to Port of Spain, which is the bottleneck for air traffic down the eastern coast of South America or westward. The West Indian route reaches numerous cities of fair size, said Major Dargue, and there is considerable commercial activity in all of them. All of the principal cities have good harbors, and conditions favor the use of aircraft capable of landing on water.

In South America the advantages of air transport already have been recognized. Coastal routes, with perhaps an interior air-line connecting Bolivia and Paraguay, should be successful. In closing, the speaker remarked that capital, encouragement and patience are needed for the establishment of air transport in the territories he had referred to, saying also that initial efforts may not be rewarded financially in the first year or more of operation, but that perseverance will prove that Latin America presents conditions favoring the addition of several profitable airways.

International Flying in Canada and the United States

In his address on International Flying on the North American Continent, Mr. Wilson confined his remarks to the area of some 6,000,000 sq. miles north of the Mexican border, a territory in which there is but one international frontier. Its inhabitants, numbering some 130,000,000, spring largely from common stocks, speak a common tongue, share a common history and literature, and have their civilizations based on the same essentials although the forms of Government differ. For these reasons, as well as for the fact that Canada and the United States are blessed with natural resources unequalled in variety and profusion, it is the speaker's opinion that the North American Continent presents today the greatest field in the world for the development of air-transport lines.

The speaker sketched briefly the history, the present conditions and the probable trend of air-transport development within the territory already described. He noted the differences in the development of aviation in different parts of the world since the Armistice. In Europe and Australia the Governments have assisted, by subsidy, in the organization of air routes connecting their principal centers. In the United States, the Post Office Department took the lead in organizing air lines for the carriage of mail. Until the contract system was instituted recently there was little or no organized passenger-traffic; but since that time there has been a great advance. In Canada, air-transport developments have been on altogether different lines. The urgent call for better means of transportation and observation in the remote districts provided a sound outlet for air-transport activities. Flying in Canada has been mainly for the conservation of the forests, the exploration and development of districts hitherto inaccessible and for transportation in connection with such work. The smaller population, greater climatic difficulties and the financial stringency of the post-war period have tended to make progress in the establishment of regular airways in Canada slower than it has been in the United States; but, in the speaker's opinion, we may confidently assume that, provided proper facilities are established, international traffic by air between Canada and the United States will increase in the same proportion as does the domestic air-traffic in Canada and that, if facilities are furnished, trade and travel by air will flow between the two countries just as it flows today on the ground. Interchange of traffic between the two countries by air is therefore a matter which calls for close attention from the respective Governments and those organizations in both countries interested in the development of aviation.

After quoting statistics regarding railroad and automobile passenger-traffic between Canada and the United States, as well as in regard to the foreign trade of both countries, Mr. Wilson went on to say that a system satis-

factory to the authorities of both countries is now in force under which it is mutually agreed that aircraft registered and licensed as airworthy by the bureau of aeronautics of the Department of Commerce in the United States and the Department of National Defense in Canada, and bearing nationality and registration marks allotted by these respective Departments, may cross the border and fly in each other's territory provided their pilots are duly qualified and licensed, and that they report to the customs and immigration authorities on entry and before leaving foreign territory.

As air traffic develops and regular services come into being, the speaker said that more formal arrangements will be necessary. It is not difficult to visualize the establishment, within a very few years, of public airports in the principal cities where special customs facilities are provided for the entry and clearance of aircraft from abroad. The lines of air traffic probably will follow routes already well defined. The main routes will be, as now, along the Atlantic Coast to St. Johns and Halifax; through northern New York by the Hudson River Valley and Lake Champlain between New York City, Montreal and Quebec; across the St. Lawrence from New York State into eastern Ontario to Brockville, Kingston and Ottawa; from Buffalo

THE CHAIRMAN AND SPEAKERS AT THE COMMERCIAL AVIATION SESSION

Past-President John H. Hunt (Center), Who Presided at the Session on International Commercial Flying in the Western Hemisphere; J. A. Wilson (Lower Right), Controller of Civil Aviation, Royal Canadian Air Force, Who Discussed International Flying between Canada and the United States; Hon. Edward P. Warner (Upper Left), Assistant Secretary of the Navy for Aeronautics, Who Discussed Overwater Flying in the Caribbean Sea; Major Herbert A. Dargue (Upper Right), United States Air Service, Who Discussed Flying in Central America; Col. H. H. Bice (Lower Left), of the Department of Commerce, Who Discussed Fundamental Aspects of Commercial Flying; George Mixter (Lower Center), of the Pan-American Airways, Inc., Who Discussed Flying between Florida and the Bahamas. Major Dargue Commanded the Good-Will Flight in 1926. Colonel Bice Represented Hon. W. P. MacCracken, Assistant Secretary of Commerce for Aeronautics

into western Ontario to Toronto and Hamilton; from Michigan through Detroit to Windsor and London; across the upper Lakes at Sault Ste. Marie into northern Ontario; from Minneapolis to Winnipeg; from the western prairie States to Regina, Moose Jaw, Lethbridge, and the prairie provinces; and from Seattle and Portland to Vancouver and Victoria on the Pacific Coast. Customs facilities will be required at these key points, where the main lines of air travel are likely to cross the border.

In closing, Mr. Wilson said that progress depends more on public opinion than on any other factor. The man in the street wants four essentials; safety, comfort, convenience, and economy. He will use air transport in the same proportion that these requirements are met.

Remarks were made by E. S. Gorrell and by George Mixter, following the presentation of the papers. Mr. Gorrell related some of his experiences while a delegate to the International Convention of Air Navigation. He said that the problem of air travel between small countries, such as some of those in Europe, is made difficult because of the different attitudes of mind and jealousies of their peoples. Mr. Mixter described briefly the operation of the Pan-American Airways, Inc., between Key West, Fla., and Havana.

American and German Diesel Engines Described

Papers Covering Their Design and Construction and Aluminum-Alloy Pistons in a Wide Size-Range Presented

In opening the Diesel Engine Session, Friday morning, Prof. C. A. Norman, who presided, said that it was a pleasure to see such a large attendance at a meeting for discussion of a subject in which automotive engineers have shown little interest in the past. While the gasoline engine is meeting the situation by the use of cracked fuel and anti-detonants, these things add to the cost. It is probable that $500 will be saved in the cost of fuel for a motor-truck during a normal life of 5 years.

German operators of Diesel-engine trucks report that they pull better on grades than do trucks with gasoline engines. At a meeting of the American Railway Fuel Association, attended by the chairman, operators of Diesel engines had more to say concerning the ease with which their locomotives were handled than about the saving of approximately two-thirds of the cost of fuel for an oil-burning steam locomotive.

Presenting first the paper by Dr. Wilhelm Riehm, of Maschinfabrik Augsburg-Nurenburg, Germany, and then a paper of his own which is printed elsewhere in this issue of THE JOURNAL, R. J. Broege, of the Buda Co., was the first speaker of the session.

Attempts have been made to use heavy oils in engines fitted with carbureters. Dr. Riehm shows in his paper, by means of curves, the essential difference between fuels suitable to use with carbureters and those suitable to use by the Diesel method. Heavy oils meet with fundamental difficulties in the carbureter engine because the compression of such an engine should be raised to secure vaporization, and at the same time it should be reduced because of the low ignition point.

Because pressures are greater in Diesel engines than in carbureter engines, some rotating and reciprocating parts must be made heavier.

Pistons and stationary parts of gasoline engines are said by Dr. Riehm to be generally heavy enough for Diesel engines, and he places the total weight of a light Diesel engine at 10 to 15 per cent more than that of a gasoline engine of the same displacement.

DIESEL ENGINE PERFORMANCE COMPARED

Mean effective pressures of gasoline engines can be almost if not quite matched, and the ordinary rotative speed of motor-truck engines can be equaled. Therefore, said Dr. Riehm, a Diesel engine is 10 to 15 per cent heavier than a corresponding carbureter engine for approximately the same power.

Considering the different types of Diesel engine, air injection is said not to be suitable for automotive use because of the space requirement and weight of the compressor. The antechamber and pressure-atomization systems deserve the most consideration. In the former, the fuel is partially burned before reaching the working chamber. In general, the paper is devoted to engines of the pressure-atomization type.

Many years of operation have shown that it is not difficult to construct reliable fuel pumps, and the injection nozzle is said to be about equivalent to a spark-plug. Both of these units are described and illustrated in the paper. Regulation of the quantity of oil injected, corresponding to throttling a gasoline engine, is secured by opening a relief valve at some point during the delivery stroke of the pump determined by the position of the governor or by a manual control. Timing of the injection, corresponding to timing the ignition of a gasoline engine, is secured by a change in position of the cam-followers of the pump.

Automobile Diesel engines that have been produced by the M.A.N. have been modifications of gasoline engines produced by the same company. New models are now being built and others are being designed, some of them of considerably larger size.

Results of tests and observation of operating experience are reported in the paper. While it is quite possible to operate the engine at various speeds with a single timing of the injection, tests show that a material gain in power is obtained by proper timing. Tests also show that the torque rises appreciably as speed is reduced. Driving experience confirms the tests in this regard and motor-trucks with Diesel engines are said to be easy to drive because of the good "lugging" ability.

Other qualities ascribed by Dr. Riehm to the Diesel engine are that it responds more quickly to the throttle than does the gasoline engine and is its equal in reliability and ease of handling in traffic. Satisfactory applications of the same type of engine have been made in rail-cars, small locomotives, miscellaneous industrial uses, marine propulsion, and auxiliary marine service.

BROEGE AND TREIBER PAPERS PRESENTED

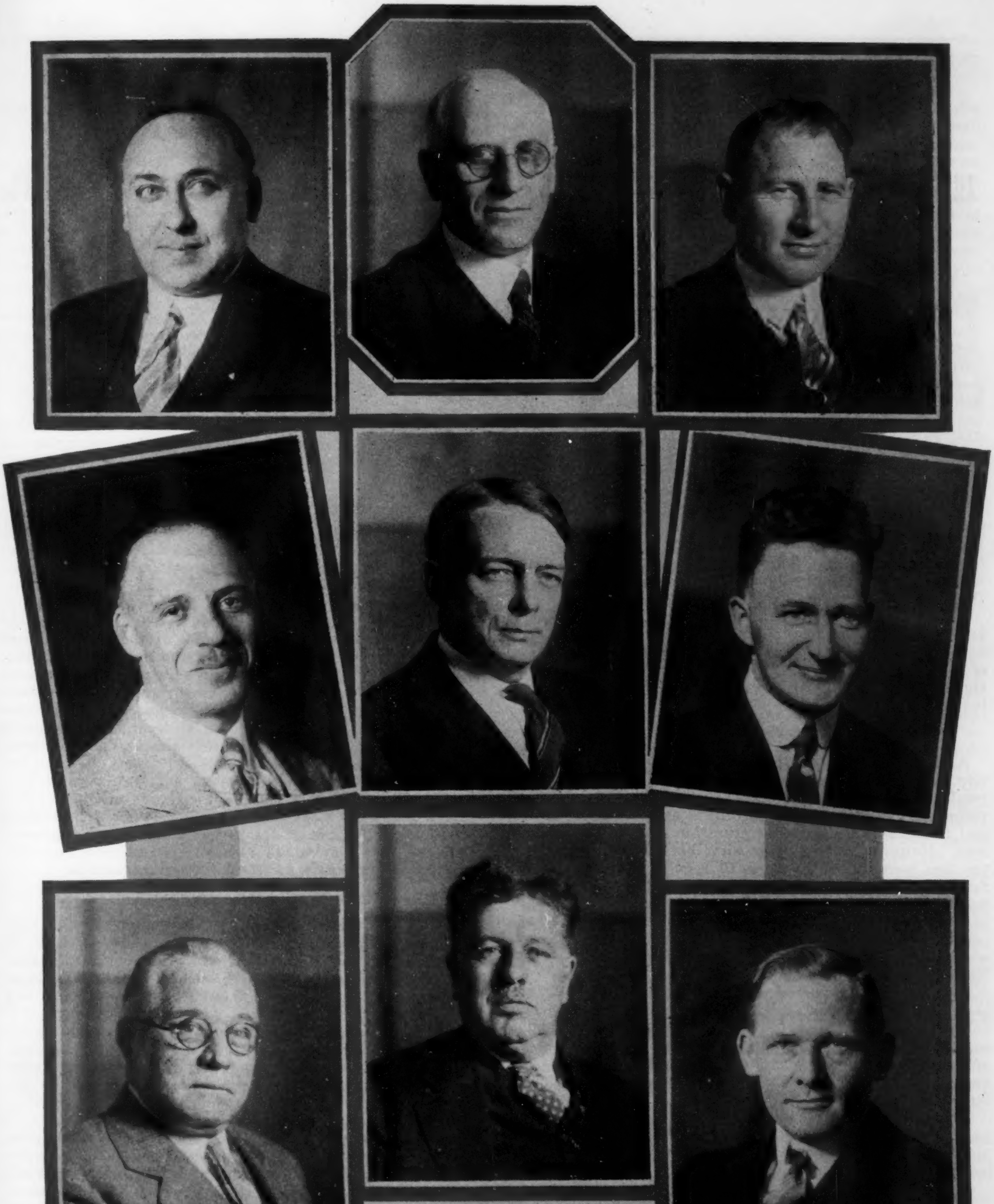
After Mr. Broege had presented his own paper on the engines being built by the Buda Co., based on the M.A.N. design, O. D. Treiber, of the Treiber Diesel Engine Corporation, presented his paper on High-Speed Diesel Engines. This paper is also printed in full in this issue of THE JOURNAL.

In opening for discussion the subject of high-speed Diesel engines, Chairman Norman referred to researches by Dr. F. Sass reported in the *Zeitschrift des Vereines deutscher Ingenieure*[1] and digested in *Mechanical Engineering*.[2] It is

(*Continued on p. 266*)

[1] See *Zeitschrift des Vereines deutscher Ingenieure*, Sept. 10, 1927, p. 1287.

[2] See *Mechanical Engineering*, November, 1927, p. 1232.



Speakers at the High-Speed Diesel-Engine Session

C. A. Norman (Upper Center), of Ohio State University, Who Presided at the Diesel Engine Session; O. D. Treiber (Upper Right), of the Treiber Diesel Engine Corporation, Who Discussed the Fundamental Limitations of High-Speed Diesel Engines; R. J. Broege (Upper Left), of the Buda Co., Who Presented a Paper on Results of Recent American Development Work on the M.A.N. High-Speed Diesel Engine, Published in This Issue, and Who Presented Dr. Wilhelm Riehm's Paper on High-Speed Automotive Diesel Engines; H. A. Huebotter (Center Right), of the Butler Mfg. Co., Who Discussed Aluminum-Alloy Pistons; and L. M. Woolson (Center Left), of the Packard Motor Car Co.; Harte Cooke (Lower Center), of the McIntosh & Seymour Corporation; L. F. Burger (Lower Left), of the International Harvester Co.; J. B. Fisher (Center), of the Waukesha Motor Co.; and O. C. Rohde (Lower Right), of the Champion Spark Plug Co., Who Took an Active Part in the Session

Metropolitan Section Show Dinner

Engineers of Car Manufacturers Tell of Improvements To Be Found on Their Cars at the Show

Automobile Show Week, for 431 members and guests of the Society, opened with the Annual Metropolitan Section Show Dinner in the east ballroom of the Commodore Hotel, Monday evening, Jan. 9. As has been the custom for several years past, engineers of the various car manufacturers were invited to tell at this meeting of the improvements that have been made in their new cars. The President and President-Elect of the Society and an officer of the Society of Motor Manufacturers and Traders, of London, gave to the meeting an international flavor. As the diners looked up at the speakers' table and saw so many of the big guns of automobile engineering, some felt a little apprehensive of the results of a broadside. Although cooperation among these engineers has been greatly fostered by the Society, they were not pulling together enough for that and no catastrophe resulted. In fact, the traffic control secured from the green, yellow and red lights of a regular street traffic signal was so excellent that everything moved in an orderly fashion.

Music during the dinner was furnished by a piano, a banjo and a drum manipulated by three men who added more color to the dinner than could be contributed by men of the Caucasian race. The drummer was such a good shouter that he got the diners to singing familiar songs between mouthfuls.

Police Department Called In

Although nothing on the menu warranted such a situation, a dispute arose between two of the diners before the meal was over. The two bewhiskered and silver-starred volunteer policemen who stood guard at the door rushed in and tried to settle the altercation but met with poor success. However, one of them blew his whistle, whereupon the two were joined by 8 or 10 regular bluecoats of the famous "Finest." After considerable difficulty this force was about to take their captives away, but at the request of Chairman E. F. Lowe the culprits were released and the officers took their revenge by displacing the orchestra, when they were revealed as the double quartet of the New York Police Department.

The policemen rendered a number of selections in very acceptable style. Not only did they command sufficient volume to be well heard throughout the room but they gave some real music. Particularly appreciated were solos by officer Brexler, a tenor, who sang several times in solo and duet on a wave length that penetrated all local interference.

One of the interesting features of the dinner was a large paper bag that was given to each diner, containing souvenirs presented by various firms in the automotive trade, including the following:

American Hard Rubber Co.	Rubber cigarette holder
Robert Bosch Magneto Co., Inc.	Eversharp pencil
Feroda & Asbestos, Inc.	Mints
Heller Bros. Co.	6-in. Master wrench.
Indiana Lamp Co.	Automobile side-lamps
International Motor Co.	Motorcoach
Monroe Equipment Co.	Leather key-holder
S. K. F. Industries, Inc.	Ash tray
Spicer Mfg. Co.	New York City guide.
Titeflex Metal Hose Co.	Diary
U. S. Chain & Forging Co.	Tire-chain repair links
Westinghouse Air Brake Co.	Matches

With the dinner disposed of, Chairman Lowe extended greetings of the Section to the members and guests, particularly the visiting engineers, and then introduced J. H. Hunt, president of the Society.

President Hunt Suggests a Question

President Hunt congratulated the Section and thanked its Committee on behalf of the Council for arranging the dinner so well. He acknowledged indebtedness to the Metropolitan Section for its accomplishments, one of which was the awakening of the Detroit Section, which he recognized as a member of that Section.

The President disclaimed any attempt to interfere with the plans of the chairman but asked as a personal favor that each of the engineers should, in describing the various models, tell how they can be distinguished from each other when their name-plates fall off.

Called upon as the official nominee for President of the Society this year, W. G. Wall spoke of the importance of Section activities to the welfare of the Society, furnishing a number of the best papers and serving as a means of keeping in contact with many members who cannot attend the National Meetings. Mr. Wall expressed the hope that new sections will be organized in at least three towns in the Country in the near future, and also in Paris and possibly in London.

After listening to these various engineers telling how they have succeeded in making their cars absolutely perfect for this season, we may wonder what is left for them to do during the rest of the year, but Mr. Wall expressed the belief that they would have a good average record if they did nothing more for the next several months.

Phillips Speaks for England

Speaking as a representative of an organization in London which includes representatives of importers, A. F. P. Phillips said that the dinner was a revelation to him. With the same enthusiasm there seemed to him no question that the predicted output of 5,000,000 American cars will be sold this year.

Mr. Phillips admired the effect of uniform stands at the Automobile Show, contrasting with it the effect of the competition between 106 firms exhibiting at the Olympia Show, each striving to make its stand more attractive than the others. Another contrast is that no such popular interest is shown in motor-cars in England as here.

A few years ago English automobile men had a poor opinion of the looks of American cars and thought themselves in the lead in that respect. "Today," said Mr. Phillips, "you beat us all hollow in the matter of appearance. There is no question of it and they are feeling that very much in England."

A Is for Auburn

Mention has already been made of the row of engineers sitting at the speakers' table. Several of them were leading engineers of their firms and well known for their activities in the Society, but none of them has been promoted so much during the last few years as H. C. Snow. His promotion depended upon the impartial arrangement whereby the engineers spoke in alphabetical order according to the names of their cars. When Mr. Snow first became prominent in the affairs of the Society, he was engineer for the

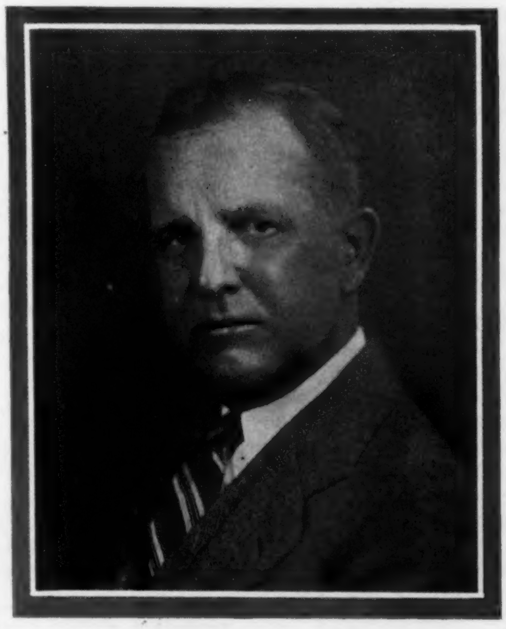
Winton Company. More recently he has been chief engineer of the Velie car, but during the last year he has been promoted all the way to the beginning of the alphabet and spoke as the engineer of the Auburn Company.

Bohnalite pistons and duralumin connecting-rods are new features of all the Auburn cars. The power of the large eight-cylinder engine has been increased to 115 hp. at 3300 r. p. m., contributing changes being an increase in compression ratio from 5.15-1 to 5.35-1 and a dual carbureter and manifold. The small eight-cylinder engine now develops 88 hp., and all the engines have thermostatic water control.

Model 15 has a by-pass in the muffler, allowing the exhaust to go directly through to the tail pipe. An unusual design of distributor outlet has made possible an ignition-cable conduit whereby all the wires are completely enclosed.

Auburn frames have been greatly stiffened, the side channels are now 7 in. deep, with 3-in. flanges, and the frames of the two eight-cylinder models have reinforcing members extending from the front to a point back of the engine. All cross members have been stiffened and the rear engine mounting now serves as a cross member. A new lubricating system reaches 20 different points on the chassis.

The hydraulic internal brakes are built with a new compensating type of master cylinder. The wheel diameter has been reduced from 19 to 18 in., with 10 exceptionally wide spokes, and the steering gear has been changed to give a constant instead of a variable reduction ratio. All the cars have hydraulic shock-absorbers. The running boards of the large eight-cylinder car have aluminum plates with through openings and metal pans to prevent splashing through upon the running board.



E. F. LOWE

Two distinctly new bodies in the Auburn line were described by Mr. Snow. One of them, called the phaeton-sedan, is a convertible body having a straight windshield, a folding top and a trunk on the back. The other is a speedster model with a boat-shaped body and a windshield sloping at a considerable angle. The removable top is supported at the back by a bar that can be dropped down flush with the top of the body.

WILSON NOW BATTING FOR DEWATERS

In the absence of E. A. DeWaters, changes in the Buick car were enumerated by F. T. Wilson who said that a double-drop frame has been adopted to lower the roof without changing head-room, wheel size or road clearance, and riding comfort has been enhanced by the addition of four Delco-Lovejoy hydraulic shock-absorbers on all models.

Chassis lubrication has been improved by making it possible to lubricate all points of the chassis without getting under the car. Access to six or seven connections is had through a small trap-door at the side. The steering wheel has been made adjustable as to position and all models are equipped with a new unit which includes the tail-lamp, stop lamp and back-up lamp. There have been changes in the exterior of the car, including a new radiator design, but Mr. Wilson is sure that it still can be recognized as a Buick without the name-plate.

Stereopticon views were used by W. R. Strickland to explain the modifications in design of the Cadillac and LaSalle cars. Attention was called to the tall radiator, the high lamps, the one-piece fenders and the emblem on the tie-rod supporting the lamps and fenders as characteristic of the LaSalle car. The same general trend has been followed in the latest Cadillac, the radiators have vertical shutters, and the drop at the bottom of the radiator gives the effect of height. An important change in the Cadillac engine is that the cylinders are now off-set to allow side-by-side connecting-rod bearings on the crankshaft instead of the forked type formerly used. The new type is more durable and will stand higher speed and higher pressure, so that one of the cars has run 950 miles in a little less than 10 hr. on the proving ground.

Double-drop frames are used on both the Cadillac and LaSalle, and the rear-axle construction is improved. A torque tube is now used on the Cadillac car. Another refinement shown by Mr. Strickland was a fuel-tank filler located outside the frame side-member, so that a trunk rack is no obstacle to filling the tank.

Representing the engineering department of the Chevrolet Motor Co., W. G. Lewellen said that he had spent 6 years in that department and had been transferred to the sales department 3 years ago; but evidently he had not yet been missed in the engineering department when their representative was selected.

Improvements in the "bigger and better Chevrolet" include the complete enclosure of the engine, a new crankcase breathing system, a two-port exhaust, a heavier camshaft driven with a fabric gear, an improved valve, and alloy pistons with invar inserts.

Mr. Lewellen admitted that the new radiator might lead one to mistake a Chevrolet for a LaSalle in case the name-plate is lost. Aside from the larger radiator, the cooling system has been improved by a wind-tunnel type shroud around the fan and thermostat regulation.

Adjustment for the brakes is provided at each wheel and application to the front and rear wheels is approximately as follows; the first inch of pedal travel puts 50 units of braking pressure on the front wheels, the next inch puts 100 units each on the front and rear, and the third inch gives about 150 units of pressure on the front and 200 to 300 units on the rear. Argument on this proportion was invited.

Four ball-thrust bearings have been added to the steering-gear, and rebound leaves have been added to the semi-elliptic rear springs. The wheelbase has been extended from 103 to 107 in. The tire size has been increased from 29 x 4.40 in. to 30 x 4.50 in.

The new bodies are larger, 5 in. being added to the length of the coupe and 3 in. to the length of the sedan. The Fisher V-V windshield is used on all models, and there is a new indirectly lighted instrument panel which includes the speedometer, ammeter and oil gage.

Regretting that he was not allowed time to go into details more fully, Mr. Lewellen assured the engineers that they can arrange to have a dealer deliver one of the cars so that they can study it at their leisure.

NEW DODGE BODY FEATURED

Chairman Lowe then introduced A. H. Knight, a consulting engineer of Dodge Bros., to tell what is left to tell of the new Dodge model after Will Rogers' announcement of the week before. Mr. Knight said that all three Dodge cars are new since last year's show. These are the Senior six which, is continued without change from recent produc-

tion; the four-cylinder car, to which Midland Steeldraulic brakes have been added; and the new Victory six, which was announced recently.

In this new car increased rigidity, reduced weight and reduced height are secured by the frame and body construction. The frame members are 8 in. deep, conforming to the outline of the body sides. The body panels rest directly on the frame, with flanges lapping over the sides through which pass six horizontal bolts on each side, in addition to the usual holding-down bolts.

The side stampings of these bodies are said to be the largest ever used in body construction, extending from the windshield post to the rear quarter in one piece, having round-cornered door and window openings stamped in them. A felt lining is cemented inside the outer shell of the body to reduce noises and to act as a heat insulator. The body sills and floor cross-members have been eliminated. The floor of the rear compartment is a steel plate resting directly on the frame, taking the minimum from the headroom.

An L-head engine similar to that used in the Senior six is used in this car. It has a seven-bearing crankshaft, machined all over; Bohnalite pistons; vanadium-steel connecting-rods with babbitt bearings spun in; and 3⅜ x 3⅞-in. cylinders.

Why Have a Radiator?

In speaking for the Franklin car, chief engineer E. S. Marks got a laugh with his comments on the discussion of the previous speakers on the height, shape and size of their radiators. Why have a radiator? Before a minute of his green-light time had passed, there came another laugh when Mr. Marks said that the instruments in his new instrument-board are grouped in a panel of the same shape as the radiator. He had to admit that they called their front a radiator because everyone knows it by that name.

Three-quarters of an inch has been added to the stroke of the Franklin engine, which was formerly 4 in. The 3¼-in. bore is retained. With the resulting 18 per cent gain in piston displacement and the larger carbureter, inlet passages and inlet valves there is an increase of 24 per cent in the power. A crankshaft with counterbalances at every bearing improves the smoothness of the engine. A novel feature is thermostatic regulation of the ventilation in the crankcase, cutting down the amount of ventilation in the summer time, when the oil temperature is high, and allowing more when it is more needed, during the winter.

To the 119-in. wheelbase chassis has been added a new chassis with 129-in. wheelbase, which carries a line of seven-passenger bodies and some open sport models. The longer chassis has 31 x 6-in. tires. Five-passenger cars have 4.76 to 1 axle ratio and seven-passenger cars have 5.1 to 1 ratio. Mr. Marks said that the appearance of the Franklin car has been changed very little since a year ago, but an offset in the front pillars has been eliminated and a back-up light has been added to the group at the rear.

Locomobiles To Order and Ready Made

Locomobile changes were recorded by R. W. Hastings, of the engineering department in Bridgeport. The two six-cylinder models are being built to order of customers only. In regular production are two eight-cylinder cars, one with 122-in. wheelbase, an engine developing 70 hp. at 3000 r. p. m., a rear-axle ratio of 5 1/9 to 1 and 31 x 6-in. tires. The other model is built with either 130 or 140-in. wheelbase, has an engine developing 90 hp. at 3000 r. p. m., an axle ratio of 4.8 to 1 and has 32 x 6-in. tires.

With the smaller car it is possible to accelerate from 5 to 30 m. p. h. in about 9 sec. and from 5 to 60 m. p. h. in 29 sec. The maximum speed is 65 m. p. h. and the fuel consumption is 14.8 miles per gal. The acceleration of the larger car is about the same, the maximum speed is 70 m. p. h. and the gasoline consumption is 12½ miles per gal.

Considerable experimenting was done with equalizers for the four-wheel brakes. A system with three equalizers was satisfactory in operation but rather complicated and expensive to manufacture. A system in which the equalizers between the front and rear wheels were eliminated was not considered safe for fear of misadjustment that might cause a dangerous braking condition. The system adopted as satisfactory has an equalizer between the front and rear but no equalizer between the sides. To guard against variation in pressure at the two sides from cross-shaft distortion, heavy tubular cross-shafts are used, with the operating levers located as near as possible to the center. A brake-testing machine shows a variation of less than 10 per cent between the two sides from a light foot-pressure to the full pressure.

As a parting shot, Mr. Hastings reminded President Hunt that it has not been necessary to use any name plate on the Locomobile car to distinguish it.

Freers Boasts of the Marmon

In opening for the Marmon car, assistant engineer George Freers said that the previous speakers had talked very conservatively and he would boast a little.

One of the three Marmon cars, Model 75, will be continued from 1927 with minor improvements.

Model 78 is a high-speed, high-compression valve-in-head engine developing 86 hp. at 3300 r.p.m., 1 hp. for each 2.4 cu. in. of piston displacement. The car has 120-in. wheelbase, hypoid rear axle and Bendix brakes. It develops a speed between 75 and 80 m.p.h. on the Indianapolis Motor Speedway, not on the speedometer, and will accelerate from 5 to 25 m.p.h. in 6 to 7 sec.; from 10 to 30 m.p.h. in 6 to 7 sec.; and from 10 to 50 m.p.h. in 16 to 17 sec. It will start at the foot of Uniontown Hill at 10 m. p. h. and reach the top at over 40 m.p.h. At any point on the hill it will accelerate from 5 m.p.h. in high gear. A "duplex down-draft" manifold is given credit for this performance. Many months were spent in developing this manifold, and Mr. Freers considers it about the last word on the subject.

Marmon Model 68 has the conventional L-head engine, with 202-cu. in. piston displacement, and develops 75 hp. at 3250 r.p.m.; 1 hp. for each 2.8 cu. in. displacement. This engine also has a duplex down-draft manifold and the acceleration figures of the car are the same as for Model 78.

Mr. Freers offered a chance for argument with the statement that he believes these two engines to develop more power per cubic inch than any other engine in the market. However, the signal light allowed no time for cross traffic and the policeman had already taken all of the fight out of the gathering, so the belief went unchallenged.

Paige Was the Name in the Program

Speaking of name-plates, L. Thoms represented the only cars with a new one, the Graham-Paige line. A day or two later one of the salesmen at the show was asked to explain which of the warriors on the emblem represented each of the three Graham brothers.

There are five chassis bearing this name-plate, one having eight cylinders and 135-in. wheelbase, and four sixes with 129, 119, 114, and 110½-in. wheelbases. All models are said to be new. The eight-cylinder engine has a bore and stroke of 3⅜ x 4½ in. A 3½ x 5-in. engine developing 97 hp. is used in the 129 and 119-in. chassis; the 114-in. chassis has a 3⅛ x 4½-in. engine developing 72 hp.; and the smallest chassis is powered with a 52-hp. 2⅞ x 4½-in. engine.

All the engines are similar. All the sixes have seven-bearing crankshafts with 2½ to 2¾-in. diameter bearings. Water-jackets extend the full length of the cylinder bores. All engines have Bohnalite pistons, pressure lubrication carried to the crankpins and silent chain front-end drives. Exhaust valves are made from silchrome steel and inlet valves from nickel steel.

(*Continued on p.* 252)

Chronicle and Comment

The 1928 Summer Meeting

ATTENTION now centers on the 1928 Summer Meeting of the Society, which will be held in Quebec, June 26 to 29. Conferences of members of the Meetings Committee, under the chairmanship of John A. C. Warner, have already been held, at which the technical program has been tentatively laid out.

Reports of Committees

SPECIAL attention is called this month to the reports of the administrative and other committees of the Society appearing on p. 242 of this issue. Only by careful reading of these reports can the comprehensive and varied work of the Society be appreciated.

Cuba's Second Highway-Transport Congress

CUBA'S Second Highway-Transport Congress will be held in Havana on the 22nd and 23rd of this month. President Machado's administration is making rapid progress toward completion of the 721-mile Central Highway, concerning the building of which enthusiasm was aroused at the first Congress, in February, 1926. Dr. Carlos Miguel de Cespedes, Secretary of Public Works, has extended a cordial invitation to the members to attend the Congress this month.

Ordnance Advisory Committee Meeting

A SESSION of the Ordnance Advisory Committee of the Society was held in New York City on Jan. 11, with representatives of the Ordnance Department. Sessions of this kind have been held for many years for the purpose of discussing automotive problems of the Army. At this last session the Ordnance Department representatives were: Majors L. H. Campbell, Jr., W. A. Capron, B. O. Lewis, Raymond Marsh, and A. B. Quinton, Jr., and Messrs. Knox and Beasley. The members of the Society Committee present were W. G. Wall, chairman, B. B. Bachman, P. E. Holt, A. F. Masury, Dent Parrett, G. A. Round, W. Turnbull, and C. F. Clarkson.

The 1928 Annual Meeting

INTEREST of the members in the technical program at the 1928 Annual Meeting was well indicated by the record attendance of approximately 1100, the largest Annual Meeting ever held by the Society. The total attendance of more than 2800 at the technical sessions, with an average session attendance of almost 300, is remarkable, and the Meetings Committee is to be congratulated on arranging a technical program and a social atmosphere that warranted such an attendance.

The news account of the meeting, starting on the first page of this issue, covers the more important engineering points brought out. Several of the papers presented also appear in this issue, and others will be published during the next few months.

Col. W. G. Wall Becomes President

AT the close of the last session of the Annual Meeting, Col. W. G. Wall, whose election was announced at the Annual Dinner, became the president of the Society for the administrative year of 1928.

The other members of President Wall's cabinet are: W. R. Strickland, first vice-president; Dr. H. C. Dickinson, second vice-president, representing motor-car engineering; D. P. Davies, second vice-president, representing tractor engineering; L. M. Woolson, second vice-president, representing aviation engineering; H. T. Woolson, second vice-president, representing marine engineering; C. R. Schuler, second vice-president, representing stationary internal-combustion engineering; C. B. Whittelsey, treasurer; E. W. Templin, J. W. White and F. G. Whittington, councilors to serve during 1928 and 1929.

The members of the 1927 Council who will hold over as members of the 1928 Council are John H. Hunt, as past-president, and Councilors S. W. Sparrow, C. B. Veal and Ernest Wooler.

Dues Deductible from Federal Income Tax

IT is stated by counsel that the dues paid to the Society are a proper deduction in making out Federal Income-Tax returns. It is further the opinion of counsel that if the dues are paid by a corporation, the corporation may properly deduct the amount as a business expense.

From Article 562 of the regulations, interpreting Section 234 of the law (Deductions Allowed Corporations), it is obvious that corporations may deduct contributions. But it also appears that dues paid by corporations are properly deductible as legitimate business expense for benefit received through membership in a professional society.

Article 105 of the regulations, interpreting Section 214 of the Income-Tax Regulations, reads in part as follows:

> A professional man may claim as deductions . . . dues to professional societies and subscriptions to professional journals . . .

1928 Nominating Committee Organizes

IN accordance with the revised provisions of the Constitution regarding the election of the Nominating Committee, Walker Gilmer, C. T. Myers and A. J. Scaife were elected members-at-large at the Business Session on Tuesday evening, Jan. 24, 1928. The organization meeting of the Committee was held at 8.30 o'clock, the following morning, when B. B. Bachman was elected chairman and D. C. Teetor, secretary. The report of the Committee will be submitted at the 1928 Summer Meeting in Quebec.

Representatives elected by the Sections who attended the meeting are: B. B. Bachman (Pennsylvania Section representative), H. F. Bryan (Chicago Section alternate), F. F. Chandler (Indiana Section alternate), Donald S. Cox (Buffalo Section representative), R. J. Emmert (Dayton Section representative), A. W. Herrington (Washington Section representative), B. J. Lemon (Detroit Section alternate), Albert Lodge (New England Section representative), George Round (Metropolitan Section alternate), D. C. Teetor (Indiana Section representative) and M. R. Wells (Cleveland Section alternate).

Personal Notes of the Members

Consultants on Braking

Under the firm name, Huck & Martin, L. C. Huck and George E. Martin have recently engaged in consulting engineering at Ferndale, Mich. The special interest of these consultants is brakes for automotive vehicles.

Mr. Huck has been connected with the automotive industry since his graduation from Cornell University in 1917. Until June, 1919, he was employed by the Diamond T Motor Car Co. with the exception of a period of 6 months in 1918, when he was student flight officer at the Naval Aviation Ground School at Massachusetts Institute of Technology. Leaving the Diamond T Motor Car Co., he worked for some time on the development of a new type of double reduction axle, forming the Huck Axle Corporation, of which he became president and chief engineer. Mr. Huck was elected a Junior Member of the Society in 1920 and was transferred to Member grade in 1923. He was for several years a member of the Chicago Section, then known as the Mid-West Section; he is at the present time an active member of the Detroit Section. A paper, Brakes for Heavy Vehicles, prepared by Mr. Huck and delivered by him at a meeting of the Cleveland Section, was published in THE JOURNAL, March, 1926.

Mr. Martin received his technical training at the Michigan State College of Agriculture and Applied Science, East Lansing, from which he was graduated in 1904 with the degree of bachelor of science in mechanical engineering. His experience since graduation has included design and production work on both passenger cars and trucks. At the time of his election to membership in the Society in 1917, he was engaged on general truck design for the Velie Motors Corporation. Since that date he has been employed successively as chief of the incoming-traffic department, Fuller & Sons Mfg. Co.; chief engineer, Walden W. Shaw Livery Co.; chief engineer, Flexo-Drive Corporation; assistant chief engineer, Huck Axle Corporation, and becoming, in 1925, chief engineer of the Huck axle division of the Sheldon Axle & Spring Co., from which position he recently resigned to enter his present connection.

Rippingille Goes to Germany

The delight with which E. V. Rippingille's many friends heard about his interesting new position was tempered by the realization that his duties will take him away from this Country. He sailed last month to become Regional Chief Engineer for Europe for the General Motors Export Corporation with headquarters at Berlin, Germany.

An Australian by birth, Mr. Rippingille received his technical training in London. For 6 years after graduation he was connected with Societe Lorraine de Dietrich et Cie., Paris, coming to New York City in 1907 to take over the management of the general repair business for the de Dietrich Import Co. Later he was in charge of engine and road testing for the Bristol Engineering Corporation, Bristol, Conn., and his subsequent experience has included important positions with Hudson Motor Car Co., Watson Stabilator Co., Rippingille and Souder, Dayton Engineering Laboratories and Delco-Remy Corporation of Dayton, with his headquarters in Detroit.

Mr. Rippingille joined the Society in 1910 and has been one of the most active members of the Detroit Section for many years. He was elected Treasurer of the Detroit Section for the current year, resigning from that office upon receiving his recent promotion.

Barling's New Connection

Walter H. Barling has recently become associated with the Nicholas Beazley Airplane Co., Marshall, Mo., in the capacity of chief engineer.

Born and educated in London, England, Mr. Barling was connected with the Royal Aircraft Factory, first as assistant chief designer and later as engineer in charge of the technical department, remaining with that establishment until 1918, when he became chief engineer of the Tarrant Aviation Construction Co. of Byfleet, Surrey, England. Mr. Barling came to this Country in 1919 and, while connected with McCook Field, Dayton, as contractor to the Airplane-Engineering Department, he designed the Barling Bomber for the U. S. Air Service. In 1921 and 1922, he was supervising engineer for the Wittemann-Lewis Aircraft Co. Mr. Barling resumed his relations with McCook Field in 1923, in the capacity of consulting engineer, later becoming a consulting aeronautical engineer in Dayton. During 1926 and 1927, Mr. Barling was chief engineer of the Cox-Klemin Aircraft Co., Baldwin, N. Y.

Mr. Barling is an associate fellow of the Royal Aeronautical Society (British) and has been a Member of the Society since 1920. He is the author of numerous articles on aeronautical subjects.

Lodge Accepts New Position

Albert Lodge has sold out his interests in the E. A. Patch Co., Boston, with which he has been connected for many years, and has accepted the position of service engineer with the Charles Street Garage Co. of the same city.

Before becoming affiliated with the E. A. Patch Co., Mr. Lodge was variously employed in experimental and testing work, as well as in maintenance. During his 12 years with E. A. Patch Co., he was first treasurer and general superintendent, later becoming treasurer and general manager. His activities included the operating and managing of two garages, a machine shop and engine-rebuilding plant in Boston, and a branch in Concord, N. H., and he has done work of a high order along the lines of rebuilding internal-combustion engines.

Since his election to membership in the Society in 1925, Mr. Lodge has been a valued member of the New England Section, serving as treasurer in 1927 and being re-elected for the current year.

Staley Connects with Climax

A. C. Staley, who was formerly consulting engineer in charge of the power division of the Northwest Engineering Co., Green Bay, Wis., is now consulting engineer for the Climax Engineering Co., Clinton, Iowa.

His connection with the automotive industry dating back to 1908, when he entered the employ of the Dayton Motor Car Co., Mr. Staley has been affiliated with the Doble Steam Car Co., the Studebaker Corporation of America, and the Stanley Motor Car Co., besides having been instructor in mechanical engineering at Yale University from 1912 to 1915, and professor of gas engineering at Purdue University for 5 years, beginning in 1921. He has also practised consulting engineering, in the field of gas and steam engineering in stationary and automotive applications.

Mr. Staley has been an active member of the Society since 1922.

Promotion for J. C. Sproull

J. C. Sproull was given the title of manager of production laboratories of the B. F. Goodrich Co., Akron, Ohio, on Jan. 1. Prior to this change, he was engineer of tests for the same company.

Following his graduation in 1905 from Rose Polytechnic Institute with the degree of Bachelor of Science, Mr. Sproull

(Continued on p. 18 of the advertising section)

Research

By Stanwood W. Sparrow

Stanwood W. Sparrow

Mr. Sparrow is well qualified to discuss the subject of research, since he has been engaged in experimental or research work for the greater part of the last 17 years. He made his start in that field when he became associated with the engineering department of the Stevens-Duryea Co. in the fall of 1911 and for 8 years was connected with the Bureau of Standards, having charge of aviation-engine testing for 6 years and being head of the automotive powerplants section from 1924 until Nov. 1, 1926, when he became a member of the engineering department of the Studebaker Corporation of America.

A RESEARCH engineer must eat. Eating requires a pay envelope, the pay envelope necessitates a job and the job requires someone who believes in the value of research. It may be that these facts are just beginning to be recognized in the automotive field, as it is only recently that any serious effort seems to have been made to "sell" research to the industry. Unfortunately the sales campaigns have left some rather erroneous impressions on the minds of those whom it was desired to reach.

For example, not a little has been said of pure and applied research and the implication has been that something of a loss in caste was likely to attend the pursuit of applied rather than the so-called pure research. Frequently, too, the value of pure research has been illustrated by citing accidental discoveries that have led to untold wealth in fields unthought of at the time the research was initiated. All this may make a fascinating story but it leaves the impression that research, particularly the "pure" type, is a rather aimless procedure; whereas the purer the research the more definite usually is the aim.

Applied research creates a fly-swatter to crush the fly that loiters on your bald dome. Pure research furnishes screens to keep out the fly, or better yet, it alters conditions until the creature has no incentive to linger in the vicinity. The distinction between pure and applied research is therefore primarily one of time. Applied research cures a trouble after it has arisen, pure research cures the trouble before it arises.

Function of Research

To pay a bill before it becomes due requires available funds. To cure a trouble before it arises requires available knowledge. It is the function of research to provide that knowledge. A research department therefore is a bank of knowledge in which is available on demand knowledge in a form to be readily applied to the purpose at hand.

The ancients used a hiding place rather than a bank for the storage of their valuables, and too often now the hide-and-hunt system is employed in the storage of research information.

If research is the curing of a trouble before it arises it might appear that the efficacy of research should be judged solely by the absence of trouble. Such is by no means the case, for the absence of trouble may indicate merely the absence of progress. The goal of research is not so much "make no mistakes" as rapid progress with few mistakes. Research should not be a matter of applying brakes to get slower motion but rather of cleaning the windshield to permit faster motion with safety.

Research has justified itself only when an organization feels secure in plunging forward with that cheerful audacity that makes the game worth while.

Notes and Reviews

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

Progress in Aeronautics. Published in *Mechanical Engineering*, January, 1928, p. 48. **[A-1]**

Containing in a brief compass the salient features of last year's developments in the field of aeronautics, this article possesses value as a summary and a source of reference. Not only are general conclusions drawn, but many concrete data are included.

The arousing of tremendous popular interest, the treatise points out, is an outstanding characteristic of the last 12 months of aviation history. In the more technical field of powerplant engineering, the predominance of air-cooling is commented on, and the new products of 10 companies are cited and described in support of this statement. While the airplane seems to have reached almost a standardized form so far as general outlines go, many novel improvements in its subsidiary parts are noted. Two typical commercial craft are described, and the one radically unusual type, the Focke-Wulf Ente, is mentioned.

In aerodynamics, the outstanding event of importance is said to be the announcement of the Daniel Guggenheim Safe Aircraft competition. Other research problems that have occupied laboratories here and abroad are enumerated. Turning to more practical topics, commercial and mail air service is pictured in three tabulations, and the outstanding inventions to facilitate aerial surveying are described briefly. The activities of the aeronautics branch of the Department of Commerce and of the Navy are reviewed and attention is given to aircraft materials and airships.

Metal Wing Spars. By John G. Lee. Published in *Aviation*, Dec. 5, 1927, p. 1342. **[A-1]**

A brief discussion of the principles and the limiting conditions of metal wing-spars as compared with wood spars introduces this article. On this groundwork, 15 types of metal construction are described, some of which are new and some of which are already in use. Comments are made on factors influencing their utility and production as well as their design.

Certain general conclusions are drawn from the study. Deep spars must, and medium-deep spars may, be trusses; the latter are preferably plate girders. Shallow spars should be single pieces. The lightest construction employs thin-walled, hollow members of rounded contour. In any construction duralumin will give a lighter spar than steel. Cheap production, easy inspection and simple repair all require open sections of heavy gage. Finally, and most important, the metal spar is essentially a quantity-production affair.

An Investigation into the Take-Off of Flying Boats. By A. Gouge. Published in *Flight*, Nov. 24, 1927, p. 810a. **[A-1]**

Rapid development will take place in the application of flying boats to commercial transport, in the opinion of the writer. Of first importance in long-range operation of aircraft are the conditions of take-off. Four factors affect take-off: the horsepower available or the effective thrust, the water resistance of the hull, the air resistance, and the wing area; and this investigation has for its object the determination of their relative importance.

Equations are developed for the calculation of the motion during take-off, and the time and length of run necessary for take-off. Assuming a maximum time of 2 min. and values applicable to a good modern machine for the various factors, curves are plotted for the limiting load with which a flying boat will take off, times to take off at various overloads with power loadings of 10 and 14 lb. per hp., and time against run to take off.

The calculations show that a good modern flying boat will leave the water at a power loading of between 18 and 21 lb. per hp., a figure which indicates the possibilities of this type of craft for long-distance operation.

Thirteenth Annual Report of the National Advisory Committee for Aeronautics 1927. Published by National Advisory Committee for Aeronautics, City of Washington. 76 pp. **[A-1]**

This report indicates that aviation has to a large extent succeeded in making itself at home in this Country, surpassing the hopes held a year ago by the National Advisory Committee for Aeronautics. The most significant characteristic of all the notable progress is said to be the increase in the number of privately owned airplanes and of commercial flying enterprises now operated without the cash subsidies that support commercial aviation in other countries.

What will be the eventual effect of aviation on the economic life of the Nation? The committee's prediction is of interest.

> In America the airplane is destined to play an important part in further enlarging this radius (of the average daily social life), and in creating new demands and new standards of life which it is hoped will lead to the development of a greater and a happier Country.

In addition to describing the present state of aeronautical development, this report outlines the organization and general activities of the committee, presents the reports of its technical committees, summarizes the technical reports issued during the year, and lists the technical notes, memorandums and aircraft circulars.

A New Type of Combined Airscrew Hub Dynamometer and Thrust Meter. By F. E. Hellyer. Published in *The Journal of the Royal Aeronautical Society*, December, 1927, p. 1150. **[A-1]**

Simpler in construction, lighter and more robust than the Bendemann hub, the apparatus herein described is said to

(*Continued on p. 30 of the advertising section*)

Automotive Research

STATUS OF AUTOMOTIVE ENGINEERING AT THE BRINK OF 1928

Seldom do the man and the task fit each other so neatly as in this instance of author and article. Austin M. Wolf's[1] qualifications for writing this summary of recent automotive-engineering developments are his long experiences in this field and his close and wide observations of details and trends. Stripped of verbiage and extraneous material, this survey makes a critical selection of and lists the salient advances in automotive design and research during the year just past.

The Research Department is indebted to the American Year Book for the use of this article, written for and appearing in that publication.

Prominent in 1927 developments are: Passenger cars with a new elegance of color and of low, sweeping lines, increased power, speed and accelerating ability; general design-refinement of chassis and body in the low-priced cars; trucks of the six-wheel type; and motorcoaches of larger seating-capacity with a floor space from end to end.

Engines

High compression-ratios with resultant increased power, greater torque at low speeds and provisions for increased life mark the new engines. There are more eight-cylinder engines in both small and large sizes.

The highest compression-ratio is 6 to 1, that of the average passenger-car engine approaching 5 to 1. The present wide distribution of antiknock fuels makes the former ratio feasible. The relatively non-detonating characteristics of the small cylinder, special combustion-chamber design, certain valve and spark-plug positions and aluminum cylinder-heads are resorted to.

Aluminum pistons have gained considerably. Due to forged aluminum-alloy connecting-rods, inertia forces are cut down materially. Piston-rings have increased in number, to five in some instances. Chromium-plated piston-pins offer wear and corrosion resistance. Full-floating pins are favored for the most part.

Inlet valves smaller than exhaust valves are usual, chrome-nickel steel being generally used for the former and silicon-chrome steel for the latter. For increased flow, a flatter inlet-valve-seat angle is used by one maker. Drilling out crankpins to a large diameter for lightness, while still retaining torsional rigidity, is used to some extent, inserted sleeves establishing the necessary oil-passageways. Increased plate friction in one torsional vibration damper is obtained at high speed by the centrifugal deformation of a lead-impregnated rubber-ring.

Through the use of chrome-nickel iron, cylinder-blocks are being obtained with a minimum Brinell hardness of 200. Pressed-steel timing-case covers; front and rear engine supports and a common drive for oil-pump and distributor, with a high location for the last named, are much used. An extended distributor-cap with molded-in plug-leads allows short bronze springs to replace the high-tension wires. The wide use of rubber engine-mountings requires a cable to ground the engine electrically to the frame. V-belt accessory-drives are popular.

Direct cylinder-wall lubrication actuated when the starter button is depressed or the choke pulled out provides anti-scoring means in cold weather. A system utilizing splash for starting only has been introduced. Cylinder-wall lubrication by the mating of a hole in the connecting-rod big-end with a duct in the crankshaft is found in many designs. Force feed to the piston-pin, through rifle-drilled connecting-rods, assures lubrication at this point. Oil-filters to be mounted directly on the engine mounting replace the former dash type. A new type of oil rectifier has a heat-conduction plug extending down into the exhaust manifold. Crankcase ventilation usually is obtained by passing cleaned air, under pressure of the fan and the forward motion of the car, into the crankcase and discharging it at the back end through a down and rearwardly extending pipe. One maker, by means of forced-draft air-cooling, taps the air duct, filters the air and, by using a thermostatically controlled valve, allows circulation when the engine is cold and stops it when a temperature of 120 deg. fahr. is reached. There is then little chance of dilution or water condensation.

Fan and water-pump rotor on one shaft have balanced thrusts. Chromium-plating is used on pump shafts. Packing glands, backed up by long bearings and copious lubrication, tend toward long life. Longitudinal cooling-ribs on top of the cylinder-head casting have been introduced. The throttling type of thermostat, without by-pass, is most popular. Most stock engines are provided with sufficient space at the water header and a flange recess to allow insertion of this unit.

Eight-cylinder V-type engines have side-by-side connecting-rods. Knight-engine improvements involve the use of two eccentric shafts, making possible shorter and lighter sleeves and reducing over-all height.

Fuel System and Manifolding

New air-cleaners have been developed. One functions as a filter type at low speed, with a valve opening into a centrifugal separating-chamber at high speed. A louvered valve-housing cover provides crankcase ventilation with air-cleaning.

Carbureter accelerating-wells are provided with a thermostatically controlled bleeder-valve which maintains more fuel in the well in cold than in warm weather. Larger carbureters are used. During full-throttle operation, a camshaft-driven booster-pump reduces the pressure in the vacuum tank. To replace the latter, one maker uses an eccentric-actuated diaphragm-pump. The metallic-disc type of gasoline filter is the latest development, being easily cleaned and providing a 0.003-in. gap for filtration.

There is an increase in the down-draft type of intake manifold. Equidistant branches, from carbureter to cylinders, are used on some six-cylinder engines. The trend of eight-cylinder in-line manifolding is toward the use of a duplex carbureter with one branch feeding the center four cylinders. More efficient hot-spots are in use, with dash control. Some exhaust manifolds run centrally over the top of the engine to a hot-spot on the opposite side. A muffler with controllable bypass lessens back-pressure at the expense of some noise.

Clutch and Transmission

Clutch throw-out units piloted on a stationary sleeve around the clutch shaft are increasingly popular, as is the rubberized disc incorporated in the driven member. A spring drive with friction damping has been introduced. Discs are larger in diameter.

Several forms of four-speed internal-gear transmission

[1] M.S.A.E.—Automotive consulting engineer, Newark, N. J.

have appeared. Considering the small ratios involved, strength and quietness, due to the large number of teeth in contact and their improved rolling action, give the internal gear an advantage over the spur gear. Study of the resonant characteristics of transmission cases caused several makers to change to different materials for them. Ball bearings have been excellent sound transmitters from gear to case, and it is now common practice to allow slight ball-play. A large bottom or side-cover plate facilitates assembly and accessibility.

Universal-Joint and Propeller-Shaft

Propeller-shafts rolled from sheet steel and welded give a more nearly constant tube-thickness, thus reducing whipping tendency. A stationary metal guard over the joints prevents grease throwing. Oil-lubricated joints have been improved for oil retention.

The torque-tube school of design has gained adherents. The three-joint propeller-shaft for trucks and motorcoaches requires a self-aligning bearing or mounting at the center. A single-row radial ball-bearing is now offered for this point, the balls being slightly undersize, allowing for limited misalignment.

Rear Axle

The semi-floating axle with independent wheel-thrust provision is used on most passenger-car models. Wheel bearing-adjustments are often made by means of shims. Faster axle-ratios are found where larger engines or smaller tires are used. In some of the heavier models, the ratios have been increased to provide greater flexibility. Because of varied conditions throughout the Country, other than standard axle-ratios are offered as special equipment. Tubular side-members, bolted to a central housing, have been reintroduced. Case-hardened truck-axle shafts are of interest. The block-type differential mounting is new.

Austin M. Wolf

Brakes

Internal brakes predominate. Four-wheel brakes are universal in the passenger-car field, with trucks and motorcoaches turning to them. Aluminum internal brakeshoes, because of their greater expansion coefficient, compensate for the greater temperature rise of the steel drums. To assure concentricity with the hub bore, the assembled wheel and drum are chucked and the latter is ground to size. Enclosed steel-cable actuation, between frame and axle, has been introduced. Cadmium-plated parts are rust-proof.

Copper lines in hydraulic systems are sheathed in a steel-wire covering for protection and are isolated from all heat. The actuating cylinder and supply tank are combined in one unit, with automatic compensation for any expansion or contraction of the liquid following temperature changes or leakage.

More sensitive vacuum-operated brakes are made possible by replacing a redesigned valve independently in the brake-rod line. A cylinder unit, pivotally suspended from a cross-shaft, with the piston connected to another shaft, gives perfect equalization between the two shafts, these cross-shafts being connected to front and rear brakes. For road-train or trailer use, a valve unit is placed adjacent to the operating cylinders, whereby air is admitted directly to each one.

The drag of an electrically magnetized plate alongside the brake-drum flange acts as a servo-mechanism for the brake within.

"Throw-away" brake-shoes, which are scrapped when worn out, are used in motorcoaches. With asbestos lining, close-grained cast-iron drums have been the most effective, being free from scaling and expanding less when heated than the usual pressed-steel drum. Slack-adjusters automatically take up excessive brake-rod movement. Heavy truck-axles have straddled-mounted anchor-pins. Dust plates are being fitted. A brake mounted on the front end of the worm shaft is popular.

No doubt legislation on the subject of brakes will soon be enacted, now that scientific apparatus has been developed for test-stand use. An electric-motor-driven transmission-dynamometer measures the braking effort at each braked wheel. Another apparatus consists of wheel-rotated flywheels possessing the same kinetic energy as the vehicle would have at a selected speed and provision for noting the deceleration at each wheel from brake application to rest.

Front Axle and Wheels

The reversed Elliot type predominates. Chromium-plated knuckle-pins, taper joints of larger diameter on the steering-knuckle arms for increased rigidity, and anti-friction knuckle-bearings, top and bottom, for ease of steering, are noted. A new tie-rod has eccentric or wedge-shaped half-cups, held against the ball stud by a U-spring. Reduction in the steering-spindle angle, particularly on motorcoaches, aims to reduce tire-tread wear.

Interchangeable wood, steel-disc and wire wheels on the same hub-equipment constitute a new development. As one shimmy-preventive, wheels are balanced before and after mounting tires. Tire and tube assemblies, as original equipment, are marked for proper valve-location to assure balance when mounted. Provision is made for balancing of wheels in service by the addition or removal of washers in groups around the felloe. One-piece forged-steel wheels of flat-spoke construction and a cast-steel wheel with ventilating spokes mounting the rim or rims directly at the spoke ends have been brought out for heavy-duty pneumatic tires.

Cushion tires for light trucks have been popular enough to bring about standardized demountable mountings. A 28 x 14-in. heavy-duty trailer-wheel has been developed, having a carrying capacity of 10,200 lb.

Spring Suspension

Negative-cambered front-springs are used to obtain low body-heights. Rear springs are longer; in one instance they are 60 in. long. Devices have been developed to give increased, constant interleaf friction. Springs are carefully graded according to each body model. Ball-bearing shackles and those of the rubber-bushing type have been introduced. The rubber-block type of mounting has been extended to amidship transmissions, gasoline tanks and truck cabs.

Frame

Frame side-rails are strengthened by use of a deeper web and wider flanges or, in one case by wider flanges, with a rolled-over lower flange. Gusset plates are being elimi-

nated by widening the ends of the cross-member flanges. A reinforcement in the front end of each side-rail assures rigidity at this point as a prerequisite against shimmy, and is a more logical stiffening means than tying-in the crankcase at four points.

Control

The standard gearshift is now universal. Higher steering-reductions reaching 18-to-1 are used. Adjustable steering-columns are toothed interlocking brackets on column and dash. To reduce road shock, one maker provides a resilient connection in the steering-gear arm. Another uses a slightly resilient steering-wheel rim of steel-reinforced molded-rubber.

Equipment

Accessories are built with special reference to their appearance when incorporated with particular car-designs. Bumpers, for instance, blend with the body line and are ornamented with the key color. Two-toned instrument-boards to correspond with the external colors and instrument panels of satin-finish nickel, engine-turned metal or hammered silver are recent developments.

A new lamp with wide beam-spread requires no bulb-focusing adjustment. A non-symmetrical system of head-light distribution is favored in which the high intensity of the beam is directed to the right of the car axis. Bullet-type head-lamps are popular. Individual vertical nickeled stanchions, often with a monogrammed tie-rod between, are replacing the fender mounting. Cowl lights are bracketed on a wide nickeled band around the front of the cowl. More spare tires are mounted at the side in fender wells. An ignition lock, with a steel coiled casing extending to the distributor and grounding the latter in the "off" position, is widely used. An ignition lock incorporated in the steering-gear lock is also popular.

Pressure-gun lubricating-fittings are grouped together at accessible points. Some central lubricating systems use a semi-liquid grease instead of engine oil. A gasoline gage on the tank as well as the dash is convenient. Windshield wipers return to the "off" position, no matter where stopped. The full-across type is gaining ground. Chromium-plating is used on radiator shells and caps, hood latches and hinges, lamps, open-car windshield-arms, door handles, bumpers and exhaust manifolds.

Sheet Metal and Body

Fenders have more sweeping lines, with the prominently beaded edge. Hoods show a variety of louvers, horizontal, narrow vertical, angular and grouped. Sometimes they are replaced by rectangular doors. Narrow and high radiators predominate, depth often being obtained by a false bottom around the starting-crank cap. Artistic filler-caps are set close to the shell, merging into the hood hinge which, at the cowl, blends into a socket decoration or a raised cowl-panel. Running-board trim hides screw and nail heads.

Low appearance, good proportions by streamlining and balanced body-design, harmonious exterior coloring and comfortable seating summarize the new bodies. "Cheat lines" are employed to deceive the eye and carry the vision along extended horizontal lines to increase the apparent length. To obliterate vertical lines, door openings are flush and barely noticeable. Along the sill a broad molding painted in contrasting color is carried back and around the fender. Moldings and reveals around the windows tie them together in a long, shallow group. Crowned roofs, dropping the roof at the rear corner and deep door-headers express lowness. Belts by their color, shape and location also accentuate this characteristic. The cadet-cap visor, door-panel color-inserts or raised oval medallions, decreased depth of the panel over the top of the windshield for greater visibility, and a distinctive ornamental motif carried through the fenders, lamps, radiator cap, door handles, instrument board and garnishing moldings are popular.

Adjustable front-seats, arm rests for the rear seats, adjustable foot-rests, metal hand-grips and form-fitting seats with saddle-spring cushions assure comfort. While harmonizing with the exterior, contrasting colors are used inside the body; the wall covering, ceiling and carpet differing from the seats.

There is a reversion to open bodies of distinctive appearance. Windshields fold horizontally forward. The convertible coupe and sedan aim to give open and closed-car advantages at will. Coupe and roadster models are sometimes provided with a sliding door in the rear deck, adapting them to commercial use, or a slip-on compartment is provided, inserted after removing the deck cover. Another commercial adaptation is a closed body with a concealed wide door at the rear provided with a detachable seat and trim in the rear compartment.

Trucks

Better weight-distribution, lessened road-impacts and increased traction have brought the six-wheel vehicle, with two rear driving-axles, to the fore. A dead rear-axle behind the driving axle is sometimes used. Six-cylinder engines, high operating-speeds for the heavier trucks through the use of dual pneumatic-tires and four-wheel brakes, four-speed transmissions on light trucks, an additional high-speed reverse, improved cab and body mountings, enhanced appearance and greater use of the trailer and semi-trailer are distinct trends. Several house-to-house delivery-vehicles have been developed with dual controls, operatable from either side.

Motorcoaches

Motorcoaches with side or rear engine-mounting instead of the conventional mounting have made all the floor space available for seating. Larger engines are used to keep down engine-speeds, as a factor for long life. Refined units allow larger mileage between overhauls. An emergency window above the rear cross-seat is operatable under all conditions. Duralumin bodies are in production. The parlor observation-coach, with an upper level at the rear, affords maximum vision and solves the baggage-storage problem. The coordination of the motorcoach with railroads, electric railways, boats and even airplanes marks its acceptance in the general transportation scheme.

Manufacturing

The increased use of standard tools with special fixtures, air-operated fixtures, hydraulic feeds, the standard spindle-nose for milling machines, gear-finishing machines and inspection devices, small-diameter internal grinding, external cylindrical-honing and diamond boring of crankshaft and connecting-rod bearings are developments in the machine-tool industry. Die-rolled I-beam axles, axle and transmission shafts, upset forgings and centrifugally cast worm-gear blanks give reduced production costs with superior quality. Improved metallographic equipment has been developed and the X-ray is being used for inspection. Improved material-handling methods start with freight-car unloading and go through foundry, machining, heat-treating, and assembly operations.

Research

The electro-deposition of rubber, ultraviolet spectroscopy of engine-fuel flames, stroboscopic study of valve-spring surge and an accelerometer-testing apparatus with a rotating-weight method for obtaining harmonic motion are major developments of the year. Of interest are antiknock-fuel tests, fuel requirements for various phases of engine performance, effect of engine carbon on detonation and corrosion caused by anti-freeze solutions. Chromium plating is being experimented with on crankshafts and sleeve-valve engine sleeves. Brake-drum heat in dual wheels, spring-leaf-stress measurements by means of a strain gage and the torsional strength of multi-splined shafts have been investigated.

HEAT-TREATING AT THE FORDSON PLANT

Continuous Gas-Fired Operation General; Camshafts Quenched between Rollers

Mass production was made possible by automatic machines. Now automatic gas furnaces, performing an almost unlimited range of heating processes, are synchronized into continuous line production. The Fordson plant of the Ford Motor Co. offers one of the greatest examples of this.

Most of the heating and heat-treating operations in this plant use gas and approximately 50,000,000 cu. ft. of this fuel is consumed every day. The gas is piped to a compressor room, raised to 15 lb. pressure and delivered to the various parts of the plant where it is utilized.

Steel making is the first of the processes in which gas is used. There are seven basic open-hearth furnaces, each of which is 70 ft. long by 22 ft. wide and of 100 tons capacity. The checkers or regenerators occupy the 25-ft. space between the charging and ground floors. A gas burner with a 5-in. water-cooled nozzle fires directly above the hearth from either side.

Every 15 min. one burner is automatically shut off and the other lighted, the waste heat being forced by the draft across the hearth and down through one of the regenerators, where it imparts much of its heat to the brick checkers, and then out through a waste-heat boiler and stack. Fresh air for combustion is drawn in through the other regenerator and by the time it passes the burner nozzle and mingles with the gas it is hot enough not materially to cool the hearth. It requires from 6 to 7 hr. to bring the temperature up to 2900 or 3000 deg. fahr. and the steel is ready for pouring in 11 to 13 hr.

Heat-treating is applied to many of the parts of the new car. The main heat-treating department, one of the largest in the world, includes 40 cyanide furnaces, 19 continuous furnaces and 6 periodic furnaces, as the principal installations, all fired with gas. The temperature of these units is maintained continuously with automatic pyrometric controls, the accuracy of which is checked in a central control room. In this room are located 66 recording pyrometers, on two wall boards holding 33 each. These recording instruments are direct connected with couples in the various furnaces and ink out lines on the charts showing the fluctuations during operation. A variation of more than 3 deg. in either direction is not tolerated in the continuous and periodic furnaces, although the cyanide units are not held so closely.

A Battery of Annealing Furnaces

Annealing and normalizing is accomplished in a group of six continuous and automatic furnaces, each of which is 24 ft. long, 8 ft. wide and 6 ft. high, built of brick and suitably insulated. One of these furnaces is shown in Fig. 1. Alloy-steel rails are laid on the hearth, and the work, consisting of gear blanks, camshafts, steering arms, steering knuckles, and the like, is propelled through the furnace by a mechanical pusher. This pusher is actuated by an eccentric, and a variable-speed transmission controls the pusher impulses so the work remains in the furnace during the exact heating period specified. The hearth extends 5 ft. beyond the charging end to provide room for loading.

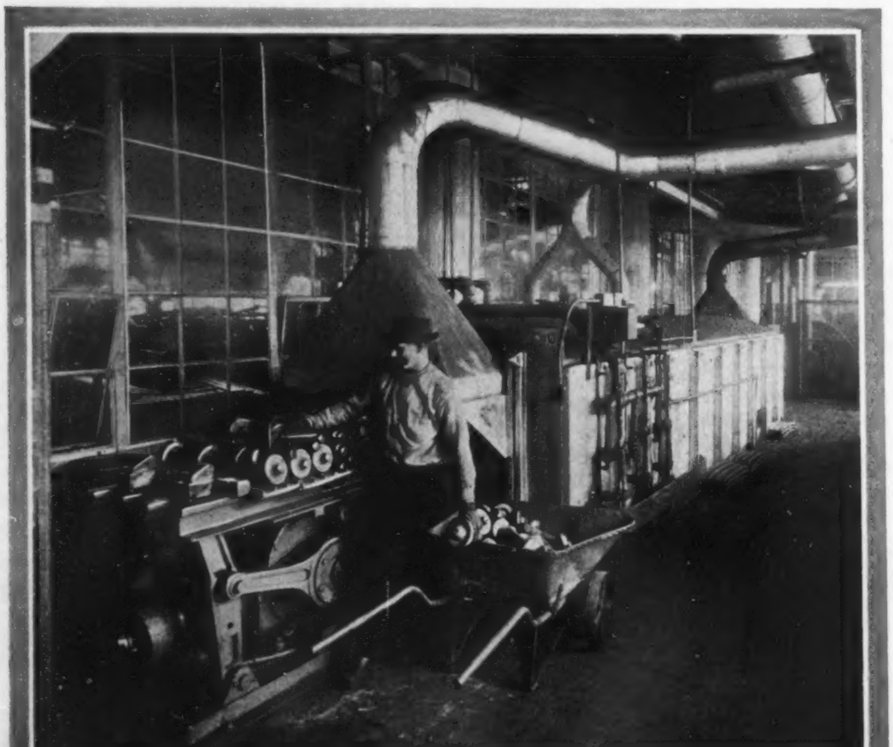


Fig. 1—Continuous Automatic Annealing Furnace

Gear Forgings as Shown, or Other Parts, Are Placed on Plates and Propelled by the Cam-Operated Pusher. A Variable-Speed Drive Controls the Heating Period

Six burners with inspirators automatically proportion the gas-air mixture for complete combustion and the proper furnace atmosphere. All these burners are located close to the loading end, in the first one-third of the length of the furnace, three on each side. Within this heating zone, a temperature of from 1500 to 1650 deg. fahr. is maintained, dropping gradually to 1150 deg. at the discharge end. The heating periods vary, according to the class of work, from 6 to 8 hr. Each of these units will heat 20,000 lb. of work in 24 hr

Hardening and Drawing Furnaces in Series

Parts like the crankshafts, connecting-rods, connecting-rod caps, and gears are heat-treated in a battery of 12 continuous automatic furnaces, six for hardening and the remainder for drawing. These units are of brick, 18 ft. long, 5 ft. wide and 6 ft. high, and are underfired with three gas-burners located in the charging end, provided with inspirators.

The work, loaded on plates, is pushed through the hardening furnace on rails by a correctly timed mechanical pusher and automatically discharged into a

steel water-quenching tank that is equipped with a flight conveyor which lifts the work up and out. An operator then loads it on the hearth of the drawing furnace. A covered chute into the tank forms a water seal to prevent the entry of cold air into the furnace at this point. The drawing furnaces are exactly like the hardening units, and the work is discharged into wheelbarrows for loading into tumblers. After tumbling it is ground, Brinell tested and trucked to the machine shop.

Hardening furnaces are maintained at from 1470 to 1590 deg. fahr., and drawing units at from 600 to 1200 deg. fahr., according to the work. The heating periods for these operations range from 45 min. to 1¼ hr. The work passes through the tandem units continuously and, except for the charging after the quench, automatically.

Novel Camshaft Quenching

The camshaft is treated in a continuous furnace 14 ft. long and 5 ft. square in cross-section. This unit also is equipped with a mechanical pusher and is designed for side-door discharge. It has two burners and inspirators, located at the discharge end, and the work rides through on rails laid on the hearth.

Fig. 2—Camshaft Hardening Equipment
Camshafts Are Pushed through the Furnace Mechanically on Rails, Removed with Tongs and Placed between Rollers on Three Vertical Shafts While Water Is Sprayed on Them. The Quenching Machine Is Shown Open at the Right

When up to heat, the camshafts are removed by an operator with tongs and put into a quenching machine, designed to prevent warping. This machine, which can be seen toward the right in Fig. 2, consists of an upright cylindrical tank, containing three vertical bars with sets of rollers, that are clamped around the shaft to hold it straight while water is sprayed upon it. The camshafts are not drawn. The hardening furnace is heated to 1470 deg. fahr. and the work remains in it 45 min. The output of this unit is 400 camshafts in 8 hr.

Piston-pins are carbonized in a furnace 30 ft. long, 8 ft. wide and 6 ft. high. It is equipped with rails and the work, in boxes, is pushed through by a mechanical pusher. There are 20 gas-burners and inspirators, which produce a temperature of 1750 deg. fahr., and the work is subjected to this heat for 6 hr. to produce a case 0.0044 in. thick. The pins are packed with carbonizing material in nichrome-steel boxes, 52 pins to a box, and a chain fall is provided for loading and unloading. When discharged, the boxes are set aside to cool before the pins are unpacked for hardening in cyanide at 1600 deg. fahr., in which the pins are heated for 6 min. They are quenched in water.

For hardening finished machined parts, such as transmission gears and differential pinions, a battery of 20 gas-fired cyanide furnaces is used. There are two sizes of pot, one 16 in. in diameter and 25 in. deep and the other 25 in. in diameter and 20 in. deep. These are set in circular brick foundations, hooded to remove fumes and fired with one gas-burner and inspirator each.

Cyanide Used To Prevent Scaling

A device for suspending the gears in the heating fluid consists of a specially designed wheel or frame parallel to the fluid surface and just above it. The gears are strung on short rods ending in hooks and these are hung on the wheel. Each pot and wheel will accommodate 16 such hooks. Into other pots the work is simply loaded, a batch at a time. These pots are held at 1500 deg. fahr. and the work is heated from 6 to 15 min., depending upon its characteristics. In this operation cyanide was chosen as a heating medium to prevent scaling, not for case hardening.

One steel quench-tank accompanies every two cyanide furnaces. Some of these tanks are provided with frames, on which to hang the work, that are given a rotary motion about a horizontal axis to produce agitation. The temperature of the oil in these quench-tanks is kept down by recirculation through coolers. A furnace 22 ft. long, provided with a chain conveyor, is used for drawing at 600 deg. fahr. for 1¼ hr.

Miscellaneous parts, such as steering-knuckle pivots, gear-shift rods, steering-arm balls, flywheel studs, and reverse-idler shafts, are treated in a battery of five cyanide furnaces fired with one gas-burner each. Some of this work is drawn in oil or nitrate baths after quenching in water. The drawing mediums vary in temperature from 450 to 800 deg. fahr., according to the class of work.

Preventing Distortion of Clutch-Plates

Clutch-plates are treated in a group of four gas-fired cyanide furnaces, at a temperature of 1600 deg. fahr. and for a period of 5 min. To prevent warping, a quenching machine is provided that holds each plate tightly between jaws while it is sprayed and then automatically ejects it. The plates receive no draw.

A single cyanide furnace is provided for certain gears, which are heated to 1470 deg. fahr. for 20 min. These gears weigh 22 lb. each and are treated in batches of 10. They are then water quenched, the time limit being 40 sec., to prevent cracking, and drawn in oil at 450 deg. fahr. In another section of the plant is a group of 66 gas-fired cyanide pots for case-hardening gears, brake-drums, transmission discs, clutch fingers, and other parts.

The bevel-drive gear is annealed in a unit 23 ft. long, and 8 ft. square in cross-section. This is fired with two gas-burners and one inspirator on each side, located close to the charging end so as to provide both a heating and a cooling zone.

A 7-ft. charging table, rails, mechanical pusher, and indicating pyrometers are part of the equipment of this unit. The gears, which are 8 in. in diameter, are piled on trays, 45 to a tray, and the trays are pushed through the furnace at the rate of 6 per hr. The hot zone is maintained at 1640 deg. fahr. and it takes the work 5 hr. to travel through.

In the whole plant there are between 400 and 500 furnaces and heating processes in which gas is used for fuel.—J. B. Nealey, American Gas Association.

Standardization Activities

S.A.E. VISCOSITY NUMBERS ADOPTED

General Acceptance of System by Car Manufacturers and Oil Refiners

The response with which the proposed use of the S.A.E. Viscosity-Numbering System has been met by motor-car builders and oil refiners indicates the great need for a systematic means of recommending grades of oil which the S.A.E. Viscosity Numbers supply. To date approximately 20 motor-car, motor-truck and engine builders have signified their intention of putting the numbers in use. Many of these car companies have already issued new instruction books, or have them on the press, and others are being prepared at this time using the S.A.E. Viscosity Numbers for their lubricating-oil recommendations.

Approximately 30 oil refiners have placed, or are about to place, the S.A.E. Viscosity Numbers on their packages and in their instruction charts to facilitate the purchase of grades of oil as recommended.

In order that a clear understanding may be had as to the reasons underlying the promotion of the use of this system by the Lubricants Division of the Society, the following article has been prepared by E. W. Upham, of the Chrysler Motor Car Corporation, and Chairman of the 1928 Lubricants Division of the Standards Committee. This paper was delivered by Mr. Upham at the Standards Committee Meeting on Jan. 25, during the Annual Meeting, and is reprinted here for the information of all interested.

Importance of Specifying Oils by S.A.E. Viscosity Numbers

In order to show why the lubricating-oil viscosity-numbers should be adopted, one must first go back and find out why lubricants needed to be standardized. To tell the story correctly, the whole history of lubricating oils would have to be given. The development of the present numbering system is the result of considerable labor on the part of the Lubricants Division of the Standards Committee and was only accomplished by the cooperation of the technical men in the oil industry. Then there is the application of the system, and what it will accomplish.

The most important property of an oil in determining suitability for use is the viscosity or "body." The real lubricating-value of an oil is dependent on its viscosity at the temperature at which it is used. Viscosity is a factor in cold-weather starting. It is also a factor in oil consumption.

This has long been recognized and viscosity was made the basis for the grading of lubricants by the refiners and the oil distributors. The terms "light," "medium" and "heavy" to name the grades were naturally chosen. As the demand for more grades grew, names for higher and for intermediate ranges were added, such as "extra heavy," "special heavy," "super-extra heavy"; and "extra medium," "medium heavy" and "special medium." The result was confusing. One company's "extra heavy" would be of higher body than their "special heavy," while this order would be reversed with another. Some adopted the letters of the alphabet as an index to their grades, either at the beginning or at the end of the alphabet; others used numbers.

While there was a general relationship between the grades of lubricant of the different companies, that is, a medium oil of one company had about the same body as another company's medium, this was not always so. Company "X" markets an oil labeled heavy, company "Y" markets an oil of a heavier body and labels it medium. A number of like cases could be given.

This situation is not pictured in order to criticise the oil companies or the general oil-marketing industry. It was a development of years and a development of companies acting individually and in competition; and there were, no doubt, good reasons at the time for the adoption of the particular nomenclature used by any one company. The general picture is given only to show the need of standardization.

SPECIFICATIONS OF VISCOSITY NUMBERS

The standardization has been effected by the lubricant engineers working together with the automotive engineers in the S.A.E. Committees and in the A.S.T.M. Committees. The first standards adopted by the Society in 1923 were based on Government lubricating-oil specifications and were never widely used. This whole subject has been admirably covered in an article by H. C. Mougey which appeared in the April, 1926, issue of THE JOURNAL.

The present lubricating-oil viscosity-numbers are the result of the combined effort of the D-2 committee of the A.S.T.M. and the Lubricants Division of this Society. They were issued as Recommended Practice in 1926.

In the work of the Lubricants Division the question of standardizing the grading of light, medium, heavy, special heavy and the like, naturally came up. That would be fine if it could be accomplished, but such grading is hopelessly tied up with trade names. The oil companies have adhered to this practice for years and it is too much to ask for a change. In fact, they simply will not change.

One point to be emphasized is that this numbering system represents a change from the original idea of the Standards, in that, instead of "purchasing-agent" specifications, they are a standardized grading based on viscosity only. In other words, instead of being an aid in the purchase of lubricants by the automobile manufacturers, they are essentially an effective means for recommending lubricants by the car builders to the dealer and the car owner.

Speaking from the experience of our own company, besides the problem of how best to handle the recommendations in the instruction books, there was correspondence with dealers and individual owners covering a wide range of questions on oils in general. We do not invite or encourage dealers to submit samples. Nevertheless, the samples would arrive and some action on them was required. The usual determinations of physical constants were made and reply given as to the grade we would advise using on the basis of viscosity and pour-test, stating that the choice based on the quality or degree of refinement of the lubricant was up to the dealer himself to decide.

INSTRUCTION-BOOK METHODS

At a recent meeting of the Division a survey was made of the Instruction Books of several automobile companies. In general, the methods used could be classified under the three following heads:

(1) Listing the trade names and grades of the lubricants considered suitable
(2) Listing one trade-name and grade and recommending that one or an equivalent
(3) Describing in general terms the lubricant desired. For example, "a medium, well-refined oil"

The first method involves endless labor on the part of the testing laboratory and tends to be unduly descriminat-

ing due to inability to cover all lubricants sold. The objections to the second method are obvious. In certain cases some oil companies have considered these two methods to be so discriminating that they have declared a boycott on the automobile companies to cause them to change their recommendations.

The disadvantage of the third method is that a general description of a lubricant cannot be made sufficiently definite; and that, if an attempt were made to make it definite, it would be technical and the average car-owner would not understand it.

Automobile manufacturers admittedly build cars that will operate successfully with average lubricants that are on the market. However, they realize that the use of well-refined lubricants of proper viscosity means greater satisfaction to the owner, better oil-mileage and reduced carbon-deposits.

Automobile manufacturers generally believe in trade-name lubricant-buying by the car owner, as it tends toward the use of the higher-grade lubricants. There is always the filling-station operator who cannot resist the easy profits of buying low-grade oils and selling at the standard prices. Manufacturers of trade-name products take pride in them and I believe honestly attempt to establish a good standard and adhere to it in quality and uniformity. Their lubrication charts, while primarily for the purpose of helping sales, nevertheless were based usually on recommendations from the car builders, when obtainable, and the purchasing of oil of correct body.

The car owner who is content with buying a "quart of oil" does not have our full sympathy; but, nevertheless, as a driver owner, he has our interest. Such an individual may not read the instruction book. In such cases, stamping the viscosity number in the oil filler-cap would help considerably.

Seasonal or temperature recommendations can be covered better by the use of the S.A.E. Viscosity-Numbers. The wording in our instruction book is as follows:

> For correct engine-lubrication, a high-grade well-refined oil is essential. As a guide to the proper viscosity or body of oil for summer and winter conditions, which vary for different territories, the lubrication charts of the reputable oil companies should be consulted. In general, an oil having the body of S.A.E. Viscosity-Number 30 is recommended for summer use and for winter use, except where zero or below-zero temperatures are encountered. For the latter condition, an oil of low cold-test and a body of S.A.E. Viscosity-Number 20 or 30 is recommended.

STATUS OF S.A.E. VISCOSITY-NUMBERS

Recommendations in our instruction books on the basis of the lubricating-oil viscosity-numbers have been too recent to judge accurately of the results. Our service department, however, is well pleased; and I have yet to hear of any opposition.

The use of the S.A.E. Viscosity-Numbers by the lubricant distributors should not interfere with their present trade-name grading. They supplement the trade-name grading and enable the car owner to buy oils of the viscosity or body the car builder recommends, and of the particular brand or trade name which he himself is convinced he wants.

Adoption of the S.A.E. Viscosity-Numbers by the automobile manufacturers and by the oil-distributing companies is progressing very satisfactorily. One of the largest producers of automobiles besides our own company has used the numbers in its latest instruction-books. Assurances have been given by several others that they will use them in the next issue of their books.

Several oil companies are stamping their containers with the numbers and have issued lubrication charts incorporating them, together with their own lettered-grading. I believe I am not violating a confidence in stating that one of the largest, if not the largest, oil-distributing company, has made definite plans to adopt the numbers. Several others are contemplating their use and have given assurance of their approval.

What is needed is more publicity. Retail oil-station operators must be instructed so that when Mr. Tom Jones wants a quart of S.A.E. 30 oil, he can get it as readily as if he asked for a quart of heavy; and, in addition, by this system he should be able to obtain oil of the desired viscosity. If he believes that a certain company's trade-marked oil is superior, he should be able to obtain the desired viscosity of this particular brand. To sum up briefly:

(1) The automobile builder believes in the use of high-grade well-refined lubricants, but of a definite body or viscosity range

(2) He believes in the car owner using trade-name oils, but does not want to recommend by trade name

(3) Recommending by the present system of grading of light, medium and heavy is ineffective due to looseness of meaning and lack of standardization

(4) The S.A.E. Viscosity-Numbers provide a definitely standardized terminology for the grading of lubricants on the basis of viscosity, by which the automobile builder can tell the dealer and the car owner the body of oil he recommends to be used

(5) The placing of the S.A.E. Viscosity-Numbers on the containers and their addition to the lubrication charts issued by the oil companies is a logical development and is essential to the purchase by the car owner of the viscosity of lubricant recommended by the automobile builders.

SANDPAPER TESTS PROPOSED

Development of Standard Tests for Qualities of Sandpaper Being Considered

Among the interesting suggested subjects for consideration by the Standards Committee is one received from V. P. Rumely, of the Hudson Motor Car Co., that a need exists for a standard test to determine suitable grades and abrasive qualities of sandpaper.

The members of the S.A.E. Passenger Car Division were approached on the subject and their replies indicate a hearty approval of the suggestion. It appears that the most general practice at present is to make actual tests in the factories, involving considerable expense for these preliminary tests and no general basis for comparison as a result.

It is anticipated that a joint subdivision of the Passenger Car Division and the Production Division will be organized to investigate the subject and develop a standard procedure for testing this important item, if such specifications can be determined.

The Standards Committee is anxious to obtain the benefit of any experiences along these lines and will be pleased to receive suggestions that may be of value to the Subdivision in undertaking this work.

Standards Committee Meeting

Twenty-Three Reports Recommended to Council To Be Submitted to Ballot

The regular Standards Committee Meeting was held in Detroit on Jan. 25 and was attended by 118 members and guests to consider and pass on the 23 reports of the Ball and Roller Bearings, Electrical Equipment, Engine, Iron and Steel, Isolated Electric Lighting-Plant, Lighting, Motorcoach, Parts and Fittings, Screw Threads, and Tire and Rim Divisions, the report with three exceptions having been printed in the January issue of THE JOURNAL. In opening the meeting Vice-Chairman Scaife, who presided, stated that the reports had been prepared with considerable care and that any suggestions for changes in them should typify general practice rather than specific individual applications.

After the Standards Committee had acted on the various reports, they were passed upon by the Council and at an adjourned meeting of the General Business Session and approved for submission to final letter-ballot of the Society, following which the reports so approved will be published in the 1928 issue of the S.A.E. HANDBOOK.

The reports were approved as presented, with a few exceptions which are given below. The reference following each subject indicates the status of the reports and the page of the January issue of THE JOURNAL on which they were printed.

REPORTS REFERRED BACK TO DIVISIONS

BALL AND ROLLER BEARINGS DIVISION

BALL BEARING RADII

(Proposed Revision of Present S.A.E. Standard)

The Ball and Roller Bearings Division's report on Ball Bearing Radii, p. 113 of the January issue of THE JOURNAL, was referred back to the Division for further consideration because of objections that were submitted just prior to and considered at the Standards Committee Meeting. It was felt that further consideration should be given to the proposed revision of the S.A.E. Standard and that the tentative report of the American Sectional Committee on Ball Bearings should also be reconsidered and the two reports correlated at the same time to meet the objections that were presented. It was felt that this could be done without interfering with the usefulness of the present S.A.E. Standard.

THE DISCUSSION

H. N. PARSONS, Strom Bearing Co.:—We have some letters on this subject from which I will read the pertinent parts.

> As we understand the bearing radii listed, it is possible for the bearing manufacturer to make the radii much larger than the maximum given. In some of our bearing installations larger radii would be very objectionable. It is preferred by this company that the bearing companies specify maximum and minimum radii for their bearings so that we may know positively what we may expect. We can then make the shafts and the bearing housings with radii which will be satisfactory for the bearings.—H. W. SWEET, Fuller & Sons Mfg. Co.
>
> Apparently there is going to be some difficulty in the use of the proposed corner radii by some of the bearing manufacturers in that the resulting corner radii on the bearings will not permit of a wide enough inner-ring or outer-ring face for properly seating the bearing against the shoulder. This is particularly true of the sizes having bearing widths of 5 to 6 mm. inclusive made by some manufacturers who use minimum race depth, thus narrowing the face. In view of this circumstance, I urge and recommend that at the Annual Meeting the subject be referred back to the Division for reconsideration and also to the Sectional Committee on Ball Bearings for reconsideration in the adoption of the proposed American Standard.—H. N. PARSONS, Strom Bearing Co.
>
> It is my opinion that we are not justified in making a change at this time in the S.A.E. Standard for the reason that the present S.A.E. fillet radii are in no case greater than the corner radii of bearings made according to the proposed American Standard that it is hoped will also be an international standard, and that in the big majority of cases are less than the proposed American radii. This means that all bearings made according to S.A.E. Standard for shaft fillet will clear the fillets specified in the proposed American Standard, and likewise bearings made with corner radii according to the proposed American Standard will clear the shaft fillets specified by the present S.A.E. Standard. The adoption of the proposed standards for corner radii and shaft fillets will accomplish nothing from the production point of view, but would cause considerable inconvenience to manufacturers by compelling them to make necessary changes in their present tools. I therefore suggest that definite action be deferred on the acceptance of this proposal at this time so that arrangements can be made to go into the matter more thoroughly, especially regarding changes on the smaller sizes of bearing where the depth of the "land" may necessitate an increase by reducing the corner radii. Also, an increase in the corner radii of some of the larger-size bearings may be desirable to assure larger shaft fillets.—H. E. BRUNNER, S. K. F. Industries.

ENGINE DIVISION

FAN BELTS AND PULLEYS

(Proposed Revision of Present S.A.E. Recommended Practice)

The Engine Division's report on Fan Belts and Pulleys, p. 118 of the January issue of THE JOURNAL, on a proposed revision of the present S.A.E. Recommended Practice, was referred back to the Division because of objection made at the Standards Committee Meeting to the 38-deg. angle of the pulley groove, especially in drives for both fan and accessories such as the pump or generator.

THE DISCUSSION

R. C. SANDERS, General Motors Corporation:—I should like to make objection to that part of the report relating to the angle of the groove in the pulley. It is my impression that the greater part of the industry does not use the 38-deg. angle and that there are any number of angles between 28 and 38 deg. which will prove entirely satisfactory. The angle of the pulley and the relative angle of the belt will depend largely upon the service for which the belt is used. There are a number of drives where a 38-deg. pulley will not be satisfactory and the report should not be adopted as standard with only the 38-deg. angle specified.

WALKER GILMER:—The reports I have received from time to time show that no one is using the 28-deg. pulley and I

do not believe any single angle between 28 and 38 deg. has been determined as being entirely correct.

L. F. BURGER, International Harvester Co.:—The correspondence we have had with various companies shows that the majority were in favor of the 38-deg. angle. My information indicates that 38 deg. is the most practical because, on the average, fan belts do not always comply with the angle specified for them. Therefore I am in favor of adopting the 38-deg. specification.

J. B. FISHER, Waukesha Motor Co.:—The object in eliminating the 28-deg. angle is not to rule out anything that is in current use but to set up a standard for the minimum number of parts that can be used. The correspondence I have had indicated that the 38-deg. groove and 42-deg. belt were favored but, if they are not, it is not the wish of the Society or of the Division to eliminate anything that the majority of members feel they should retain.

E. A. BERNHARD, L. H. Gilmer Co.:—I think that probably a different angle should be used for pretty nearly every individual application if we want to have the ideal installation. But on the basis of the number of applications, the 38-deg. angle would probably be the most generally chosen. The use of the 28-deg. angle started some time ago to favor a certain condition of belts instead of drives. From a belt manufacturing standpoint we would like to have one standard.

MR. SANDERS:—The use of the 28-deg. angle is necessary on cars using a three-corner belt-drive for the generator, water-pump and fan. Because of the limited space available in many installations, it is sometimes hard to use pulleys sufficiently large to give the desired belt contact for transmitting the power that is necessary. If the arc of belt contact is small, it is essential to get all of the power-transmitting ability possible from the belt by a smaller angle in the pulley groove. A 38-deg. pulley will not do this in many cases and of necessity a pulley angle which will do it, or some other means for driving the accessory apparatus, must be used. It is in such cases that the 28-deg. pulley with a 32-deg. belt has proved more satisfactory than the 38-deg. pulley and a 42-deg. belt. If it is necessary to set some standard, some experimentation might determine that some intermediate angle, say 33 or 34 deg., might be the best.

F. G. WHITTINGTON, Stewart-Warner Speedometer Corporation:—If there is such a wide use of the 28-deg. pulley, I would say that the report should be referred back to the Division for further consideration.

VICE-CHAIRMAN A. J. SCAIFE:—I think the difference of opinion may be because, in the one case, the drive is used for the fan only and, in the other case, for another accessory also, such as a water-pump or generator.

W. R. STRICKLAND, Cadillac Motor Car Co.:—The 28-deg. belt was used a good many years ago and is now used in many cases. However, in the use of rubber belts, 38-deg. is about as steep as we would want to use. We have to use special rubber compound for even 38-deg. belts but the 28-deg. angle is used with certain types of belt where they can stand that angle for driving auxiliaries.

VICE-CHAIRMAN SCAIFE:—There seems to be quite a difference of opinion as to what pulley-groove angle should be adopted or whether there should be a compromise. We can change the report slightly by omitting that part of the sentence immediately following the words, "An angle of 38 deg. shall be used for driving fans only," or we can refer the report back to the Division. There is a motion before us to approve the report.

[The motion was voted on and lost. It was then moved, seconded and voted that the report be referred back to the Division.]

CHANGES IN REPORTS

The only reports that were modified at the Standards Committee Meeting were that on Steering-Gear Connecting-Rods, p. 126 of the January issue of THE JOURNAL, submitted by the Parts and Fittings Division, and the report of the Lighting Division on Laboratory Test for Head-Lamps, p. 125 of THE JOURNAL. In the former the limiting dimensions *A* for the 1¾-in. nominal-size ball-stud were changed to 1.785 and 1.795 in. In the latter report a new paragraph for General Information was submitted and approved as included in the account of this discussion of this report.

REPORTS APPROVED AS SUBMITTED

The reports as approved are as follows, the reference following each subject indicating the status of the report and the page of the January issue of THE JOURNAL on which it was printed.

BALL AND ROLLER BEARINGS DIVISION

ROLLER BEARINGS

(*Proposed Revision of Present S.A.E. Standard, p.* 113)

ELECTRICAL EQUIPMENT DIVISION

MOTORCOACH BATTERIES

(*Proposed Revision of Present S.A.E. Standard, p.* 114)

STORAGE-BATTERY TERMINALS

(*Proposed S.A.E. Standard, p.* 114)

ENGINE DIVISION

ENGINE TESTING FORMS

(*Proposed Revision of Present S.A.E. Standard, p.* 115)

CLUTCH HOUSINGS

(*Proposed Revision of Present S.A.E. Standard, p.* 118)

HOOD-LEDGE LACINGS

(*Proposed Revision of Present S.A.E. Standard, p.* 119)

ISOLATED ELECTRIC LIGHTING-PLANT DIVISION

For a number of years the Society has published standards for Voltage and Capacity Ratings of Isolated Electric Lighting Plants, p. 122 of the S.A.E. HANDBOOK, and for Round Pipe-Flanges, p. 214 of the S.A.E. HANDBOOK. These standards, when adopted, were approved by the lighting-plant manufacturers but subsequent developments in this branch of the industry have made them more or less obsolete. With regard to the standard for Voltage and Capacity Ratings, the Society cooperated some time ago with the Electric Power Club, which is now the Apparatus Division of the National Electrical Manufacturers Association, in revising its generator rating specification, the principal part of which is given below. The following recommendations were accordingly submitted to the lighting-plant manufacturers and duly approved by ballot of the Isolated Electric Lighting-Plant Division members for submission to the Standards Committee and the Society for approval for the purpose of bringing the S.A.E. Standard for Voltage and Capacity Ratings uptodate and to cancel the now obsolete standard for Round Pipe-Flanges.

VOLTAGE AND CAPACITY RATINGS

(*Proposed Revision of Present S.A.E. Recommended Practice*)

RATINGS FOR ISOLATED ELECTRIC LIGHTING-PLANT GENERATORS

Nominal Output, Watts	Nominal Generator Voltage	Service Voltage	Full Load, R.P.M.
500	36 and 125	32 and 112	1150 and 1720
750	36 and 125	32 and 112	1150 and 1720
1000	36 and 125	32 and 112	1150 and 1720
1500	36 and 125	32 and 112	1150 and 1720
2000	36 and 125	32 and 112	860, 1150 and 1720
3000	36 and 125	32 and 112	860, 1150 and 1720
5000	125	112	860, 1150 and 1720

BASIS OF GENERATOR RATING

(1) The standard rating of generators shall be in watts. A supplementary rating in amperes or lamps of a specified wattage may be published

(2) The rating of a generator in watts shall be the product of the full-load current in amperes and the nominal voltage

(3) The nominal speed of the generator shall be the speed at which it must be operated to develop the rated output in watts, at the nominal voltage specified above, after the generator has attained temperatures corresponding to continuous operation at full load. (These conditions apply only to operation or test.) Under actual operating conditions the speed of the generator, when it is delivering normal full-load in amperes, will usually differ from the nominal speed, as it is desirable that the terminal voltage of the generator, when it has attained temperatures corresponding to continuous operation at full load, shall equal the initial discharge voltage of the fully charged battery

The standard number of cells shall be:

Service Voltage	Number of Cells — Alkaline Type	Number of Cells — Lead Type
32	26	16
112	92	56

Note.—The voltages specified are correct only for generators used in connection with the lead-acid type of battery.

This recommendation conforms with the Standard of the Electric Power Club as printed on p. 149 of the E. P. C. Handbook of Standards, September, 1925.

Round Pipe-Flanges

(*Proposed Cancellation of Present S.A.E. Standard*)

IRON AND STEEL DIVISION

S.A.E. Steels—Chemical Composition

(*Proposed Additions to Present S.A.E. Standard, p.* 120)

Heat-Treatment Definitions

(*Proposed Revision of Present S.A.E. General Information, p.* 120)

LIGHTING DIVISION

Head-Lamp Laboratory Tests

(*Proposed Revision of Present S.A.E. Recommended Practice, p.* 121)

THE DISCUSSION

C. A. Michel, Guide Motor Lamp Mfg. Co.:—The report of the Lighting Division as published in the January issue of The Journal is rather long and I will not read it. By vote of the Division, the last paragraph of the report, which is printed on p. 123 as "General Information," should be replaced by the following:

General Information

These notes are not to be considered in any way a part of the standard Specifications for Laboratory Tests of Optical Characteristics of Electric Head-Lamps for Motor-Vehicles.

In testing head-lamps, it is desirable that the testing laboratory give careful attention to the selection of test lamps to assure results which represent average performance and to minimize variation in test data between laboratories.

As stated in the specifications, the lamps should be of standard manufacture, as shown under the heading "electric incandescent lamps" in the Electrical Equipment Section of the S.A.E. Handbook.

The axes of the filament coils should be straight and form a vee with the base toward the base-end of the lamp and with the legs at an angle of approximately 30 deg. to each other. The filament coils of the lamp should be symmetrical with approximately the same number of turns in each.

In the 6-8-volt lamps, the length of the filament along the lamp axis and the over-all width of the base of the filament should (both) be 0.100 in. plus or minus 0.005 in.

Lamps should be installed so that the filaments lie in a horizontal plane.

In single-filament lamps the geometric center of the filament should be at the approximate center of the spherical part of the bulb. In double-filament lamps, the geometric centers of the filaments should be separated by 0.140 in. plus or minus 0.005 in., and should be located directly above and below and at equal distances from the approximate center of the bulb. In double-filament bulbs one filament shall not be more than 0.005 in. behind the other.

MOTORCOACH DIVISION

Vacuum-Brake Manifold Connection

(*Proposed S.A.E. Recommended Practice, p.* 123)

PARTS AND FITTINGS DIVISION

Passenger-Car Bumper Mountings

(*Proposed Revision of Present S.A.E. Recommended Practice, p.* 123)

Woodruff Keys

(*Proposed S.A.E. Standard, p.* 123)

Oil and Grease-Cup Threads

(*Proposed Revision of Present S.A.E. Recommended Practice, p.* 125)

Taper-Fitting Tolerances

(*Proposed Revision of Present S.A.E. Standard, p.* 125)

Rivet Cap Specifications

(*Proposed S.A.E. Recommended Practice, p.* 125)

Steering-Gear Connecting-Rods

(*Proposed S.A.E. Recommended Practice, p.* 126)

THE DISCUSSION

W. C. Keys, United States Rubber Co.:—There is a typographical error in the table in this specification. For the 1¾-in. nominal ball-size, the dimension *A* which is given as 1.760 to 1.790 in. should be 1.785 to 1.795 in.

Tinners', Coopers' and Belt Rivets

At the Standards Committee Meeting in January, 1927, the Parts and Fittings Division submitted a report on the proposed tentative American Standard for Tinners', Coopers' and Belt Rivets that had been formulated by the Sectional Committee on Bolt, Nut and Rivet Proportions, which is sponsored by the Society and the American Society of Mechanical Engineers, under the procedure of the American Engineering Standards Committee. The report was submitted at that time for approval by the Society as a sponsor and was printed on p. 21 of the January, 1927, issue of The Journal. The report was returned to the Sectional Committee for a number of revisions in the tables and for correlation with the report on Small Rivets that was submitted and approved at the same time. The revised report on Tinners', Coopers' and Belt Rivets was received too late to be included in the January, 1928, issue of The Journal but was duly approved by the members of the Parts and Fittings Division for submission to the Standards Committee and to the Society for approval as a tenta-

(*Continued on p.* 264)

Operation and Maintenance

MOTOR-TRANSPORT ACCOUNTING

Classification, Accumulation, and Uses of Costs Outlined Briefly

In a recent analysis made in regard to the foregoing subject, W. F. Banks, president of the Motor Haulage Co., Inc., Brooklyn, N. Y., says that it is only natural that automotive engineers should be concerned chiefly with mechanical problems, but they should not overlook the fact that in a commercial operation or in any operation the mechanical costs constitute but a small portion of the total cost and, therefore, they should not be considered as a criterion for comparisons or judgment. Further, that it would be contrary to all engineering principles to recognize only a few facts when others are known to exist. To be of service to the industry as a whole, and particularly to the smaller-scale operators, it is essential that the operator be shown how to determine the profit or loss resulting from his efforts. If the smaller-scale operator is to be assisted in this manner he must be provided with the facilities he needs; that is, the machinery with which to determine the results of his business operations. Mr. Banks then goes on to say that in the motor-transportation industry there seems to be a continual discussion of the cost of operating motor-vehicle service, and he has yet to find any two individuals who will agree on this subject or any two organizations with cost records in such form as to permit an accurate comparison of the total cost of service, or better, the cost of doing business.

The difficulty, however, is not in any particular inaccuracy of the costs that are compiled, but in the tendency to consider only those costs that are commonly known as operating costs, often losing sight of the fact that these do not constitute the total cost of the service rendered. It also is unfortunate that costs in this limited form are frequently published without qualification, particularly when cited as the experience of a large organization whose operation is self contained and is more or less a necessary evil. Such cost figures no doubt create a misconception of the cost of motor-vehicle service, with disastrous results for the operator who attempts to use them as a basis of trading or competing.

The rate of mortality in this business is now exceedingly high. While ease of financing purchases may add to the ranks or hasten disaster, it generally is conceded by those who have studied the problem that the basic cause of most difficulties is a lack of knowledge of the total cost of maintaining the service, rather than of the so-called operating costs. This continuous use of motor-vehicles in unprofitable applications, particularly in competition with existing transportation facilities, not only establishes a market in which the intelligent operator cannot operate at a profit, but also creates a resistance tending to retard, rather than promote, stabilized motor-vehicle operation.

In spite of these unfavorable conditions, a few motor-transportation organizations have grown beyond the capacity of individual financing, and in doing so have found it necessary to protect the interests of their stockholders with an adequate accounting system and a cost system that will enable them to determine the entire cost of individual operations. If these systems are necessary for the large operators, they are desirable for the smaller operators.

The Society of Automotive Engineers, which has been responsible for a large portion of the development of the motor vehicle, and particularly for the creation of standards now used in their manufacture, is doing some real constructive work in endeavoring to establish a uniform method for determining not only the so-called operating costs of these vehicles, but also the total cost of maintaining the service they render. Inasmuch as the obligation for this work has been assumed by the Operation and Maintenance Committee, Mr. Banks presents for consideration the needs of a commercial operator in the form of an outline of a system now in use that not only pictures true conditions of the business as a whole, but also permits the determination of the total cost of any particular operation.

Classification of Accounts

The following form outlines a comprehensive system of classifying the accounts of a motor-transport business.

- (1) Direct Expense
  - Wages of Drivers
  - Wages of Helpers
  - Ferry Charges
  - Loading Charges
  - Other Direct Expense
- (2) Vehicle Operating-Expense
  - (*a*) Operating Materials
    - Gasoline
    - Lubricants
    - Tires
  - (*b*) Maintenance
    - Labor
    - Parts and Materials
    - Outside Repairs
    - Shop Rent
    - Light, Heat and Power
    - Depreciation of Shop Equipment
    - Tool Expense
    - Salaries
    - Other Maintenance Expense
- (3) Overhead Expense
  - (*a*) Fixed Expense
    - Depreciation of Vehicles
    - Cartage Licenses
    - State Licenses
    - Insurance
      - Fire, Theft and Transportation
      - Public Liability and Property Damage
      - Collision
      - Merchandise
      - Compensation
      - Contents of Buildings
  - (*b*) Garage Expense
    - Rent
    - Light, Heat and Water
    - Wages
    - Other Garage Expense
  - (*c*) General Supervision
    - Salaries of Foremen
    - Salaries of Clerical Help
    - Automobile Expense
    - Foremen's Expense
    - Other Supervision Expense
  - (*d*) Selling Expense
    - Advertising
    - Subscriptions and Dues
    - Salaries
    - Automobile Expense
  - (*e*) Administrative Expense
    - Office Rent
    - Salaries
    - Telephone and Postage

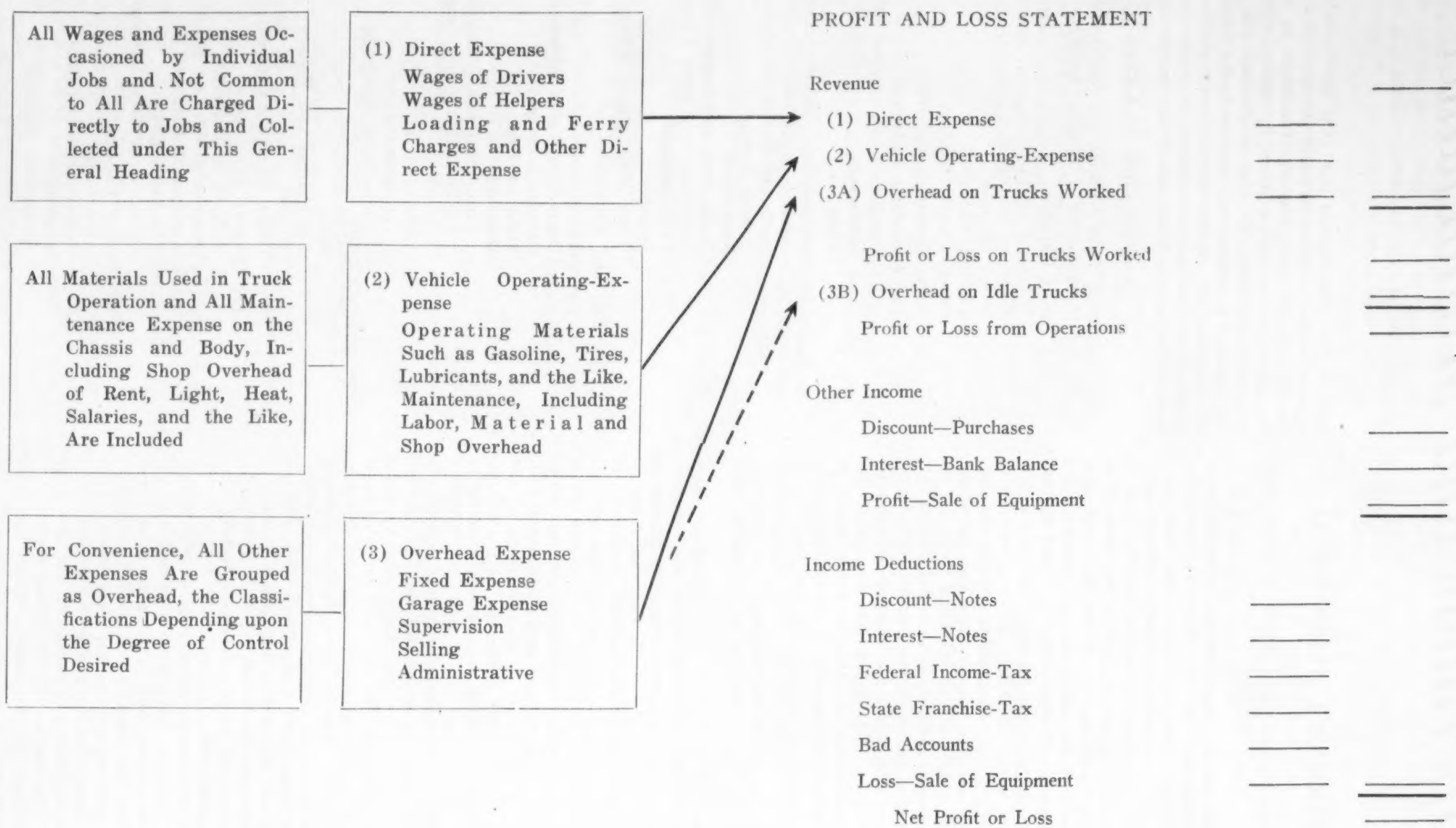


FIG. 1—FORM FOR ACCUMULATION OF COSTS

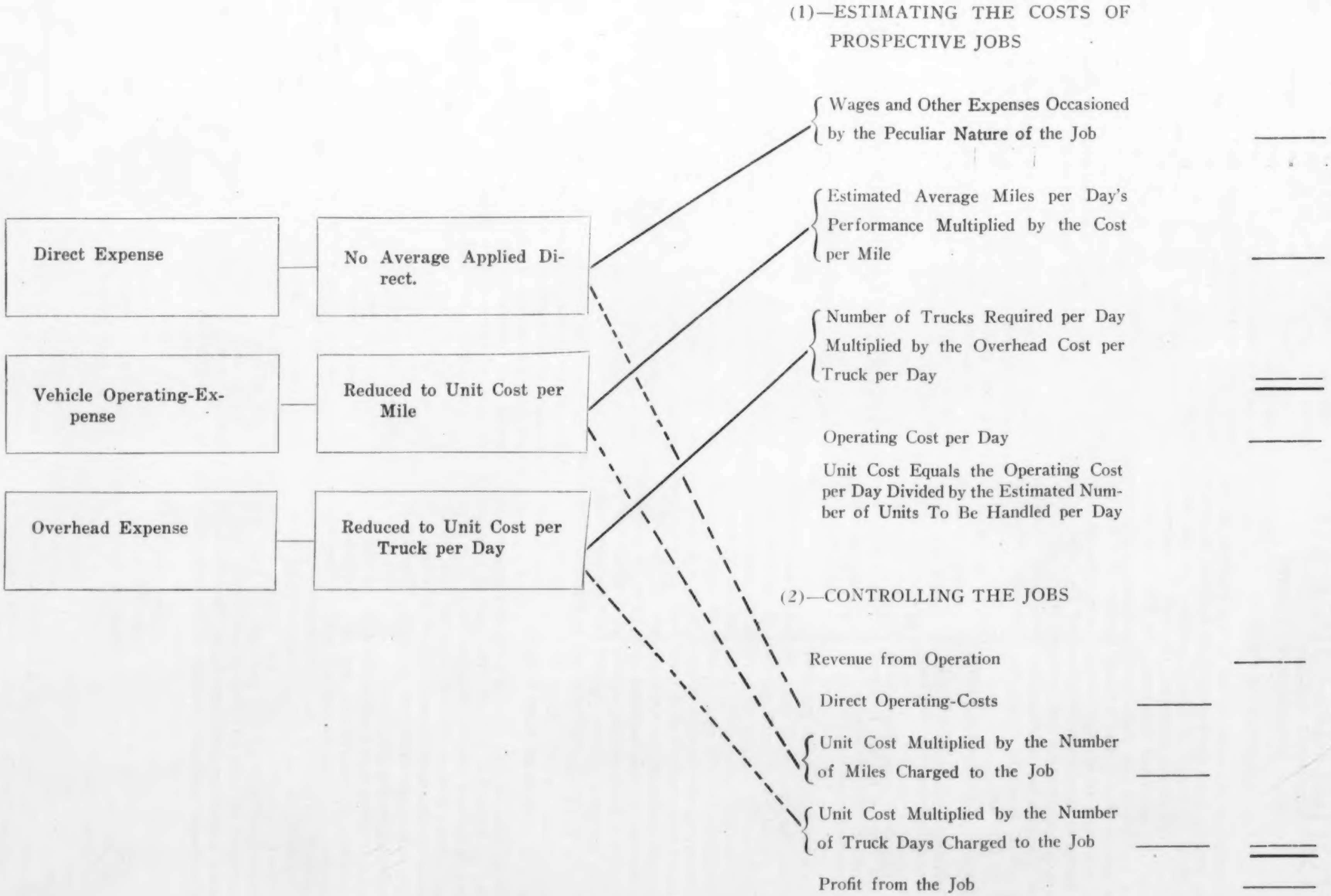


Fig. 2—Form Indicating the Proper Utilization of Costs

Stationery and Supplies
Depreciation of Furniture and Fixtures
Legal Expense
Automobile Expense
Other Administrative Expense

Accumulation of Costs

The accumulation of costs so as to be enabled to determine the results from the business as a whole is accomplished easily as indicated in Fig. 1, using only the three main groups of (*a*) direct expenses, (*b*) vehicle operating-expenses and (*c*) overhead expenses. In Fig. 1, a simple set-up of a profit-and-loss statement is shown, the entire amounts of groups Nos. 1 and 2 being applied as indicated. Group No. 3 is split in its application, as shown, so as to provide a better control. In this manner the total overhead-expense is reduced to a unit cost per truck per day on the basis of the number of days the truck was available.

The number of days the truck was available should be determined as follows:

Total Productive Equipment Owned, per cent		100
Estimated Average Amount of Equipment Out of Service for Repairs, per cent	10	
Estimated Enforced Idle Equipment Due to the Nature of the Business Which Cannot Be Overcome by Sales Effort, per cent	2	12
Net Available Equipment, per cent		88

For example, the number of days the truck was available in any given period would be 88 per cent of the total equipment owned times the number of working days during this period, the difference between the total number of days the truck was available and the total number of days the truck worked representing the number of days the truck was idle.

The number of days in which a truck was idle, expressed in money value, presents a vivid picture of one of the dangerous features of the business and, after it has been accumulated for a long period, serves as a guide for determining the accuracy of cost figures and for controlling the amount of equipment required for a given volume of business.

Uses of Cost Data

The principal uses of cost data in a motor-transport business are (*a*) to determine properly the cost of prospective jobs and (*b*) to control jobs in progress. For this purpose the same groupings of cost data are used as were made for the accumulation of costs; namely, direct expense, vehicle operating-expense, and overhead expense. The mode of usage is indicated in Fig. 2.

Direct-expense data are applied directly to the job in either estimating or controlling, and are applied in the current months. They are so applied because they are expenses occasioned directly by the individual job and cannot be applied correctly on an average basis over all jobs.

Vehicle operating-expense data are applied easiest by reducing them to an average cost per mile, as they are expenses common to all jobs. If the supposition is true that these expenses accrue on a mileage basis, then the application of the average unit-cost per mile to the miles charged to any particular job should make that job bear its proper proportion of the total cost.

Overhead-expense data, being principally expenses that accrue irrespective of working hours or distance traveled, are more easily and more correctly applied by reducing them to an *average cost per truck per day available*, as already explained under accumulation of costs. The application of this average cost per truck per day to truck days charged to a particular job makes the job carry its proper proportion of the total overhead-cost.

In applying the averages mentioned under groups Nos. 2 and 3, however, current-month cost-data should not be used; first, because one month is too short a period in which to determine average cost of any portion of a business and, second, because of the monthly fluctuation in costs, the reason being that the value of periodic comparisons on jobs would be lost if current-month averages were used.

In groups Nos. 2 and 3 of costs, there is little variation over a long period; consequently, the previous year's averages will give a more accurate picture of conditions, will serve as a fixed basis for monthly comparison of job performances, and will suffice also as a basis for measuring fluctuations in current costs.

UNIVERSITY EXTENSION COURSE OFFERED

Garage and Service-Station Management Taught by Correspondence

The Division of University Extension, of the Massachusetts Department of Education, State House, Boston, asks the following questions: Why do automobile owners patronize one garage or service-station and pass up another? Would it not be worth your while to make a study of a matter so important to the success of a business? The statements are then made that there is a widespread demand for reliable and economical repair service and that this business will go to the shop which can give satisfaction.

Garage and Service-Station Management is the title of the new course prepared especially to cover the planning, equipment and efficient operation of a service station, to present means for extending service, and to serve as a guide for members of the service organization in the solution of their service problems.

The bulletin received states that the subjects of the course are selling service, labor charges, service organization, service-station layout, service-station equipment, costs, stock-room procedure, shop management, and the handling of claims for missing or damaged parts.

This course can be completed by correspondence in 8 to 10 weeks. The cost of $6 includes a textbook, lesson paper and the correction of home work. Those who desire to enroll for the course can obtain an application form from James A. Moyer, director. Enrollment is made by mailing this application to the director and including with it the $6 fee.

Certificates issued by the Massachusetts Department of Education will be granted to those who complete the course in a satisfactory manner.

The Automotive Full-Diesel Engine

By R. J. Broege[1]

Annual Meeting Paper — *Illustrated with* Photographs and Charts

A compressorless, solid-injection, full-Diesel engine of four-cycle operation, as developed by the Maschinenfabrik Augsburg-Nürnberg, Germany, for application in all industrial automotive installations, is discussed by the author. A 50-hp. M. A. N. engine installed in a 4-ton truck has performed as well as a gasoline engine of the same bore in the same truck, but with greater fuel economy and more lugging ability. It has been as easily handled and requires no more attention.

The American-built four-cycle engine has a 6-in. bore and an 8-in. stroke, and its design does not deviate from the principles involved in the German engine. The only purpose of changes has been to conform to S.A.E. Standards and to adapt the engine to American practices.

The entire construction is very similar to that of the heavy-duty automotive-type gasoline engine and holds to approximately the same weight per horsepower, with practically no more space required for installation. The engine can be started by electric starters or by a two-cylinder air-cooled gasoline engine. Its operation is controlled by two levers regulating the fuel-pump, which replaces the magneto. Careful attention has been given to accessibility of all moving parts.

The popular demand for Diesel engines is due primarily to their economical operation and the lesser fire risk compared with that accompanying gasoline operations. In presenting this paper, no effort is made to compare the different makes of Diesel engine nor any Diesel engine still in the experimental or development stages, but it is particularly confined to an automotive full-Diesel engine developed in 1923 and sold in Germany to the commercial trade, one that has been proved out in actual service under private and individual ownership. Since 1925 this engine has been applied to commercial trucks, motorcoaches, motorboats, cranes, rail-cars, electric generator sets, and the like.

The American-built Diesel with which this paper deals particularly is built under a license and to the patents of the Maschinenfabrik Augsburg-Nürnberg, Germany, generally known as the M.A.N. To give an idea of the development leading up to this engine, it may not be out of place to mention that Dr. Diesel developed the original Diesel engine in the shops of the M.A.N. and was connected with them until his demise.

Fig. 1 shows the first 20-hp. Diesel engine, which is still on exhibition in the Deutschen Museum, Munich, Bavaria, Germany. Fig. 2 shows a 15,000-hp. Diesel engine built under the M.A.N. license. A good idea of the size of this engine can be obtained by comparing with it the size of the men shown standing on the different platforms. I understand that this is the largest Diesel engine in actual operation, and it gives some idea of the possible wide range of power capacities to which Diesel engines can be applied. It is hard to say when a larger size may be built, but a larger size is not improbable.

The commonly known Diesel engines equipped with air compressors are built in one-cylinder and various multi-cylinder types; from the earliest to the latest, they range from 20 hp. to 15,000 hp. per engine. They are considered complicated, very heavy, and expensive to build, weighing as high as 75 to 300 lb. per hp. The larger engines are of very low speed, from 70 to 100 r.p.m., and the smaller sizes hardly exceed a speed of 300 to 450 r.p.m. For many years it was thought impossible to build these engines more simply and lighter, but the demand for light and higher-speed Diesel engines for submarine service opened the way. The advancement in the Diesel submarine engine indicated greater possibilities in other lines. Consequently, an automotive compressorless solid-injection full-Diesel engine of the four-stroke cycle was developed. Fig. 3 shows a four-cylinder 50-hp. truck-engine of this type which is also built in a six-cylinder model having the same bore and stroke as those of the four-cylinder engine. These automotive Diesel engines should in no way be compared with the commonly known slow-speed heavy Diesels of either the air-injection or solid-injection types.

I believe it is fair to state that the automotive high-speed Diesel engine is here and has already gone through many of the stages that the present-day automotive gasoline-engine has gone through before reaching its present highly developed stage. This type of automotive Diesel engine will perform economically with cheaper fuel over a wide range of service, such as in commercial motor-trucks or in excavator machinery, equally as well as gasoline engines and with far better fuel economy and less fire risk. It will perform equally well in any other service for which the gasoline automotive engine is used.

The engine shown in Fig. 3 has a 115-mm. ($4\frac{1}{2}$-in.) bore and a 180-mm. ($7\frac{1}{8}$-in.) stroke. One of these Diesel truck-engines has been in service for several months in a truck owned by the company I represent and has been put in parallel service with that of our gasoline-engine trucks. It is of 50 hp. and weighs 1100 lb. It was installed in a well-known 4-ton-truck chassis made in this Country, and no alteration was required in the length of the hood or in the radiator.

Fig. 4 shows the service and performance of this Diesel-engine truck as compared with a gasoline-engine

[1] M.S.A.E.—Chief engineer, Buda Co., Harvey, Ill.

truck. Both trucks are of the same make and capacity and perform the same service. No special attention is given other than regular periodical inspection and greasing. The 4-ton gasoline-engine truck has a four-cylinder engine of 4½-in. bore and 6-in. stroke.

The Diesel engine was installed in a similar chassis without any view of experimental development and wholly for practical purposes to learn how gasoline-engine-truck drivers would comment upon it and how it would handle in traffic, such as in Chicago. Learning to operate this Diesel-engine truck required no more effort or time than to learn to operate a gasoline-engine truck. In addition to the greater economy, the driver soon discovered that the Diesel engine had far better lugging ability than was the case with the gasoline-engine truck.

Contrary to general belief, the cooling of this Diesel engine was far easier than was that of the 4½ x 6-in. four-cylinder gasoline-engine. The same radiator was used as for the gasoline engine and, during the summer months, the water never heated sufficiently to raise the temperature so that the red fluid would come up to the average running mark on the motometer. When cool weather began, it was found necessary to provide the radiator with a shutter to keep the engine up to a temperature suitable for good operation.

Engineering Features

Fig. 5 shows the automotive compressorless solid-injection full-Diesel engine built by our company. It has a 6-in. bore and an 8-in. stroke, and is of four-cycle operation. The view at the left is of the fuel-pump side and shows the fuel filter, the fuel dividers, the inlet and exhaust manifolds, and the elbow for air-filter application. At the right is a view of the water-pump side of the same engine. It shows the lubricating-oil tank equipped with a sight glass, the lubricating-oil dual gear-type pump and its piping and filter, the crankcase breather, the centrifugal water-pump, the removable push-rod cover-plates, the cylinder-head covers and the nozzle clamps.

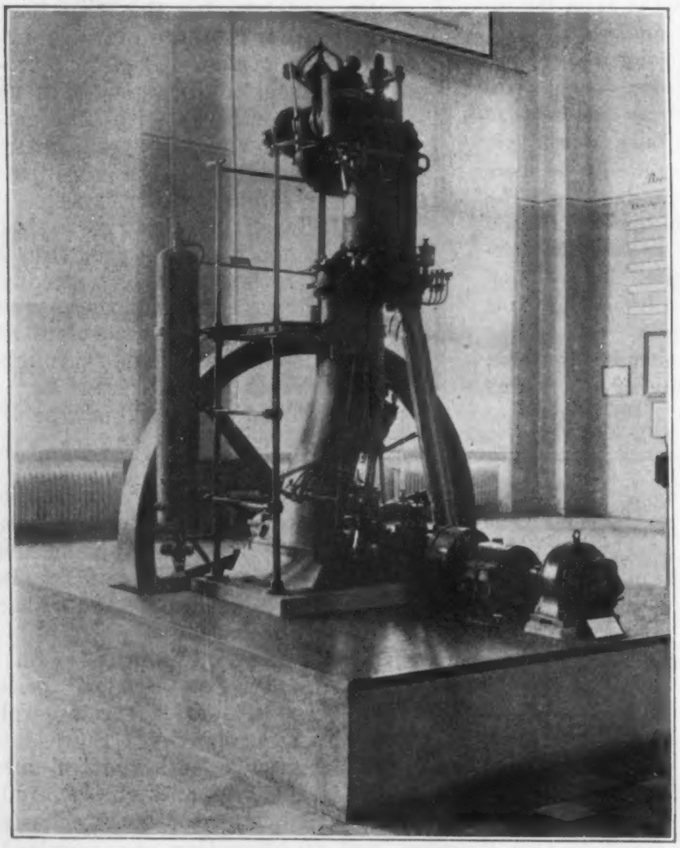


Fig. 1—The First Diesel Engine Which Operated Successfully

This Engine Is on Exhibition in the Deutschen Museum at Munich, Germany

In the design and construction of the American-built engine, no attempt was made to deviate from principles involved in the M.A.N. design. The only purpose was to make their already highly developed engine more adaptable to American standards and practices and to simplify it where possible to aid service and production. Fig. 6 shows a cross-section of this engine.

The crankcase and cylinder-housing are of boxed construction cast-in-block integrally for any number of cylinders. This produces a rigid and light design and causes the engine to operate very smoothly. The cylinder proper comprises a gray-iron inserted sleeve which is readily renewable. The main babbitt-lined bearings are suspended in the crankcase and secured by inserted bolts, there being a bearing between each two cylinders.

The oil-pan is of aluminum to secure lightness so that it can be easily dropped, as in most automotive-type gasoline-engines, for bearing adjustment. Provision has also been made for removing the pistons and their rods from the bottom; but they can also be removed through the top if desired. Hand-holes are provided on the side of the crankcase for connecting-rod-bearing adjustment.

The crankshaft and the flywheel are balanced both statically and dynamically. The flywheel is provided with a steel starting-gear and is enclosed in a No. 00 or a No. 0 S.A.E. flywheel-housing, the latter being the smallest one practicable because of the necessity of using a large flywheel to produce energy for starting and to assure steady operation.

Starting and Control

Either electric starters or a two-cylinder air-cooled double opposed-piston gasoline-engine can be used for starting purposes, either system being arranged with a gear drive automatically engaging the ring-gear on the flywheel. To aid the initial turning-over of the engine, a manually controlled compression release has been provided. After the engine is spinning, compression can be engaged on one cylinder until it fires, after which all cylinders can be engaged.

The valves are located in the cylinder-heads and are operated by rocker-arms and roller push-rods. Valve-tappet adjustments can be made conveniently by removing the cylinder-head covers, which leaves the rocker-arms in plain view without obstruction by accessories or other parts. The valve-in-head design is used to obtain the desired compression space for the most efficient pressures. The inlet-valve has an integral deflector on the head which, with the angular direction of the fuel spray, produces the necessary turbulence for the complete mixture of air and fuel that is necessary to produce clean combustion. The cylinder-heads are cast in pairs to secure lightness and to facilitate easy removal, and are protected by safety-valves.

The air-inlet pipe has a pre-heater attached to aid in starting under extremely cold conditions and is arranged for the application of an air-filter. The exhaust pipe is large and has an outlet flange suitable for attaching a muffler.

All parts are completely enclosed but are readily accessible after removing the hand-hole plates, push-rod or cylinder-head covers, each of the last two being held by one hand-nut. Cooling is accomplished by using a conventional water-pump of centrifugal type which is driven off the gear train. Provision is made for generator drive from the extended water-pump shaft.

Lubrication and Other Features

Force-feed lubrication to all moving parts, by a dual geared pump operating a dry-sump system, is a feature of the engine. Oil is taken from the supply tank mounted on the flywheel-housing; thence, the pressure pump forces it through the filter to the main and camshaft bearings. From the main bearings, the oil goes to the crankpins and up the drilled connecting-rods to the wristpins. It is also forced to the rocker-arm assembly and to the fuel-pump. The timing-gears are lubricated by a jet of oil directed to each pair at the point at which the gears mesh.

The oil from the main bearings and all other moving parts drains to the bottom of the sump-pan, from which the sump-pump returns it through a screen to the supply tank. Mechanical lubrication of the pistons has also been provided for if desired. The constant oil-pressure

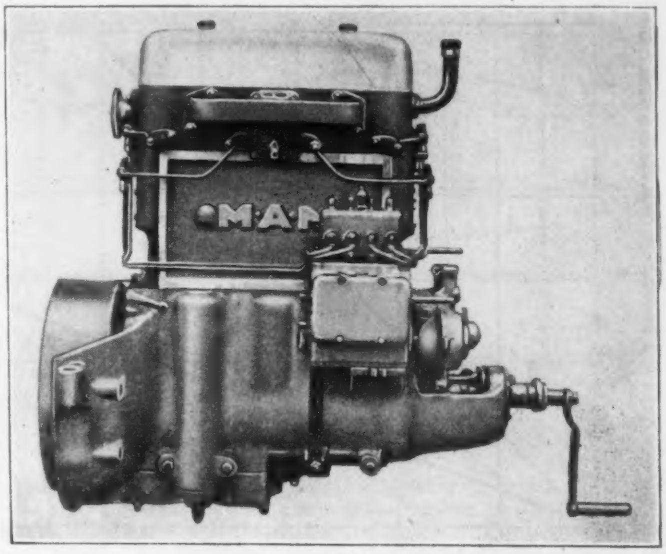


Fig. 3—Full-Diesel Truck-Engine

This Is a Compressorless Solid-Injection Engine Operating on a Four-Stroke Cycle. It Has Four Cylinders and Develops 50 Hp. A Six-Cylinder Model of This Engine Is also Available

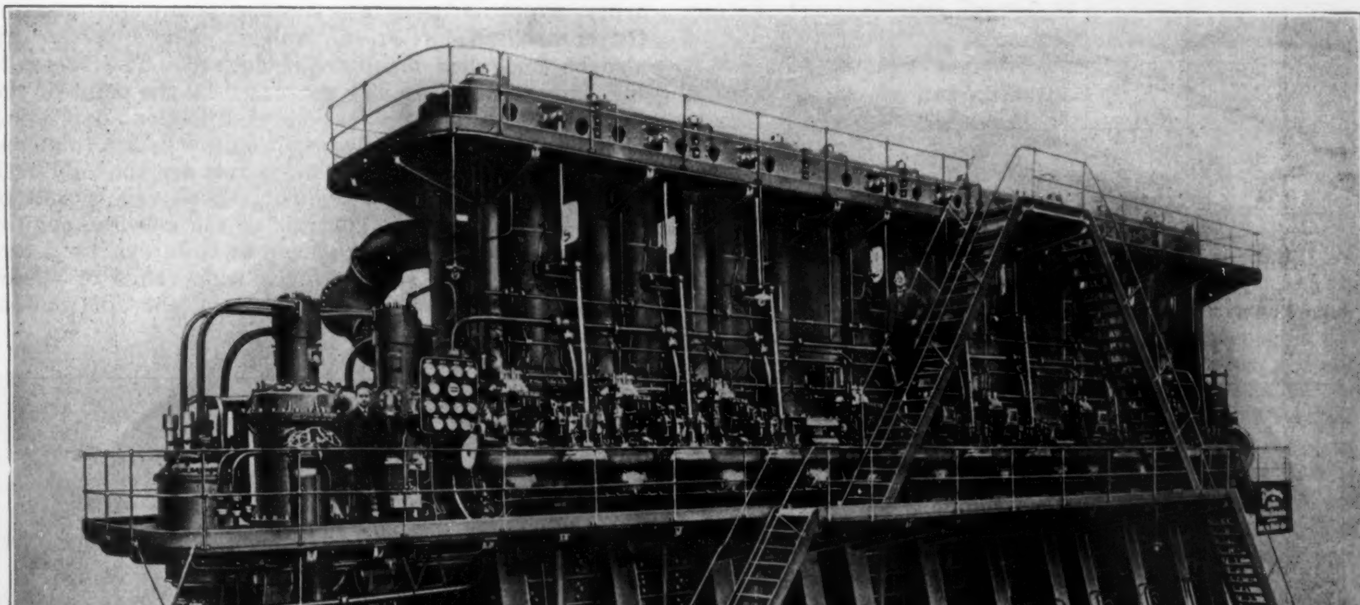


Fig. 2—Diesel Engine of 15,000 Hp.

This Engine Was Built under M.A.N. License. A Good Idea of Its Size Can Be Had by Comparing with It the Size of Men Shown Standing on the Different Platforms

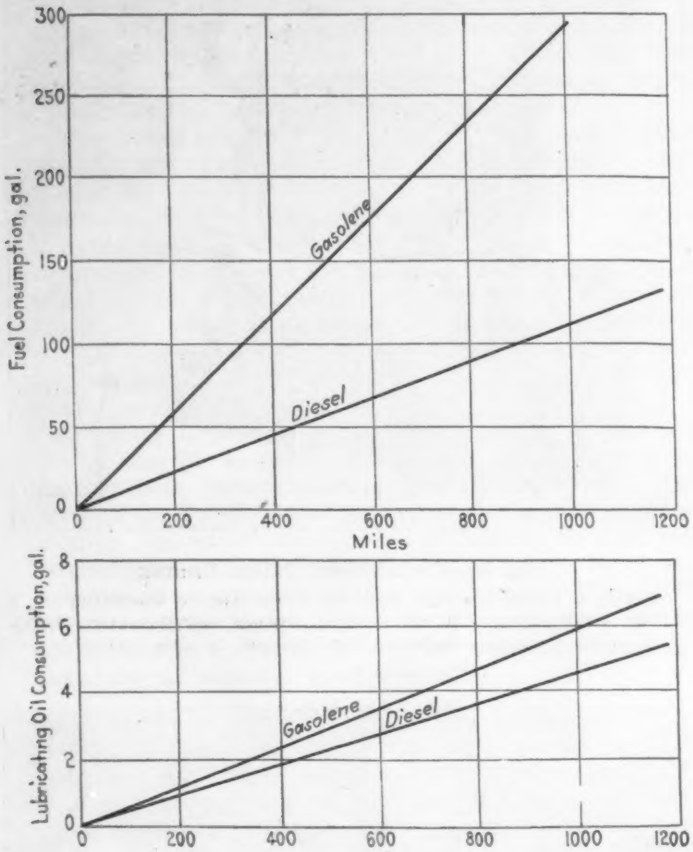


FIG. 4—GASOLINE-ENGINE VERSUS DIESEL-ENGINE PERFORMANCE

The Curves Are for the Engine Shown in Fig. 3 When Installed in a 4-Ton Truck in Comparison with Those Obtained from a Gasoline Engine Installed in a Similar Truck of the Same Capacity

is maintained and protected by safety valves. All oil passes through screens before entering the pumps, and then through the filter before it reaches the moving parts. The dry-sump system helps to accomplish this and also enables the engine to be operated at any reasonable angle without leakage and without starving any bearing surface.

Careful consideration has been given to accessibility of all working parts for ease of inspection and servicing. The integral crankcase and cylinder-housing with walls between cylinders from top to bottom gives a very rigid construction and permits the use of much thinner sections, which tends to decrease the weight of the engine.

The fuel-pump is mounted on a bracket integral with the crankcase and is positive, being driven off the timing-gear train. It is a cam-actuated plunger type with a plunger and a cut-off valve for each engine cylinder. The cut-off valve and plunger are actuated by fulcrum tappets interposed between the main-drive cams and the plunger and cut-off valve. The cut-off valve can be adjusted easily in the same manner as when adjusting ordinary valve-tappets. All moving parts are enclosed in a common housing and operated by one drive-shaft having integral drive-cams.

The engine-speed actually is controlled by the governor, which is built into the fuel-pump and operates the controlling, or cut-off, valves. These valves can also be controlled manually if desired. The speed of the engine is increased or decreased by the point of the fuel cut-off and the duration of injection, depending upon the plunger and valve position in relation to piston position and speed. The two controls are the only ones for operating the engine and correspond very closely to the spark and gasoline controls of the gasoline engine. The fuel-injection advance-lever location can be determined and located readily for a wide range of speed, and the engine is then controlled by the fuel cut-off

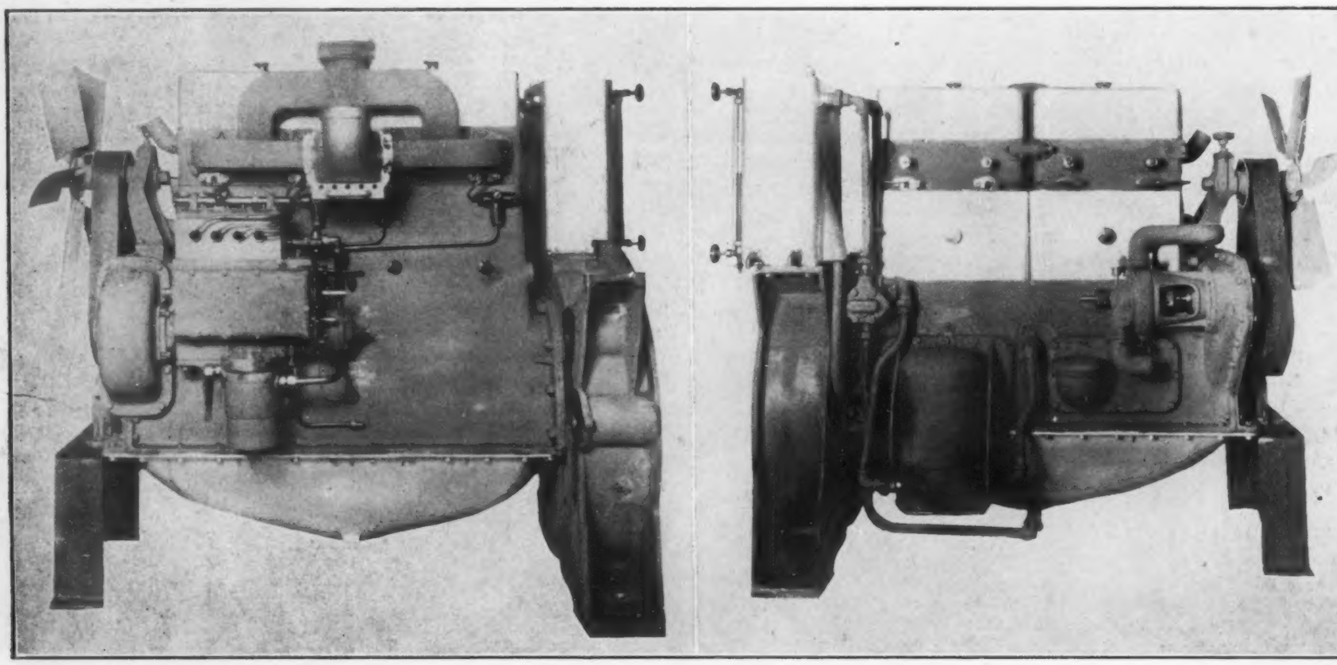


FIG. 5—AMERICAN-BUILT FULL-DIESEL ENGINE

At the Left Is Shown the Fuel-Pump Side and at the Right the Water-Pump Side of the Four-Cylinder Four-Stroke-Cycle 6 x 8-In. Compressorless Solid-Injection Full-Diesel Engine Built by the Buda Co.

lever the same as is accomplished by the carbureter-control lever on a gasoline engine. Contrary to popular belief acquired from the older types of stationary Diesels, this engine is very simple to operate and requires a period no longer for training operators than that required for gasoline engines.

The nozzles are of the open-end solid-injection type. They have one single opening and are all interchangeable. They are as easily removed and cleaned as spark-plugs are, and they do not require cleaning any oftener than spark-plugs do because the fuel is filtered very carefully through special filters of fine metallic gauze before entering the fuel-pump, from which it passes

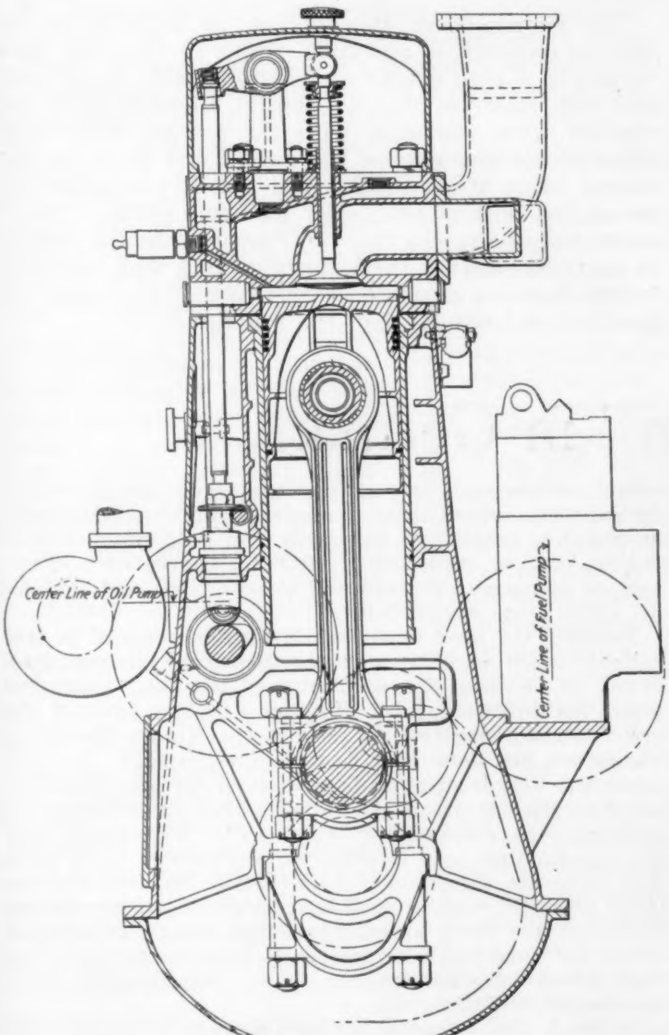


FIG. 6—CROSS-SECTION OF THE ENGINE SHOWN IN FIG. 5

through to the injection nozzles. The fine gauze is of such mesh that any foreign matter which can pass through it will also pass through the nozzles, thereby eliminating the possibility that the nozzles will become clogged.

Figs. 7 and 8 are charts of the relative performance of this Diesel engine and a gasoline engine of the same bore, both having been tested on the same dynamometer at the Armour Institute of Technology. The charts give a rather clear conception of the operating economy of the Diesel over that of the gasoline engine. This economy in fuel consumption is not counteracted by any

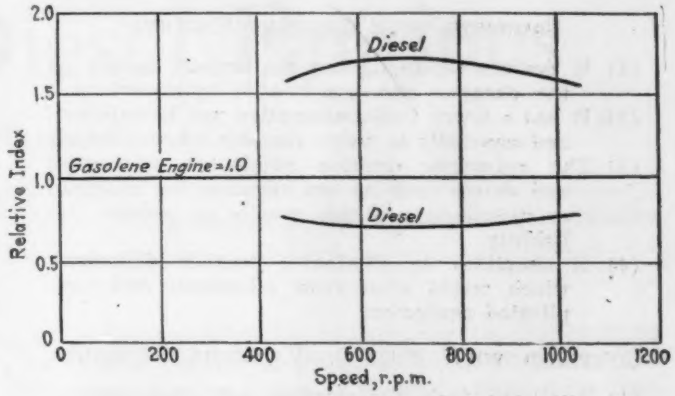


FIG. 7—DIESEL-ENGINE VERSUS GASOLINE-ENGINE PERFORMANCE

The Upper Curve Shows the Relative Number of Hours of Operation of the Diesel Engine on the Same Volume of the Respective Fuels. The Lower Curve Shows the Relative Fuel-Consumption per Work Unit of Diesel Engine in Pounds of the Respective Fuels

TABLE 1—ANALYSIS OF THE THREE FUEL-OILS USED

	Test Fuel		
	No. 1	No. 2	No. 3
Specific Gravity, deg. Baumé at 60 deg. fahr.	38.2	34.3	26.0
Carbon Content by the Conradson Test, per cent	0.006	0.03	2.57
Flash Point by the Pensky-Martin Closed-Cup Test, deg. fahr.	160	225	200
Water and Sediment, per cent	0.06	0.10	0.10
Heat Units per Pound, B.t.u.	19,675	19,590	19,234
Sulphur Content, per cent	0.31	0.63	0.78

other operating costs, for, as illustrated, the simplicity of design and accessibility of all parts keeps labor and maintenance costs at the minimum. Up to the present, tests have been conducted with several grades of fuel.

Table 1 gives the analysis of three grades of fuel and shows their wide range, which will give a corresponding wide source of supply. The engine burned each of these fuels equally well during all tests. In addition to the light weight, the small space required and its simplicity as compared with the conventional air-compressor-injection Diesel-engines, this engine has many other points of merit when compared with other types of engine.

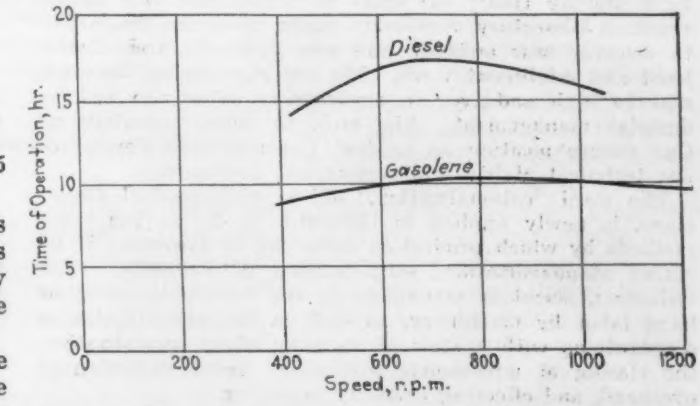


FIG. 8—RELATIVE PERFORMANCE CURVES

The Curves Are from the Diesel Engine and a Gasoline Engine of the Same Bore, Both Having Been Tested on the Same Dynamometer, and Show the Number of Hours of Operation per 100 Gal. of Fuel at 100 B.Hp.

COMPARED WITH GASOLINE ENGINES

(1) It derives its fuel from the largest supply of the cheaper and non-volatile hydrocarbons
(2) It has a lower fuel-consumption per horsepower, and especially so under variable load-conditions
(3) The automatic ignition eliminates accessories and drives such as are required for magneto or distributors, which results in greater reliability
(4) It simplifies or eliminates possible difficulties which might arise from additional and complicated equipment

COMPARED WITH FUEL-OIL-VAPORIZING ENGINES

(1) Auxiliary fuels for starting are eliminated
(2) It is always ready for starting
(3) It has improved adaptabilities for automotive purposes
(4) There is no contamination of lubricating oil by fuel oil

COMPARED WITH ENGINES OF IGNITION-CHAMBER TYPE

(1) The cylinder-head construction is more simple, especially considering provision for starting
(2) The possibility of requiring auxiliary fuel for starting is avoided
(3) Ignition cartridges or electric ignition-coils, with their necessary batteries, are eliminated
(4) It has better adaptability to the commercial automotive trade and to any other work for which the automotive gasoline engine is used
(5) The operation with a cold engine or under no load is more uniform, even at low speeds

COMPARED WITH HOT-BULB ENGINES

(1) It has lower fuel-consumption, especially under heavier loads
(2) It weighs less
(3) The lamp for heating the hot bulb is eliminated
(4) It is always ready for starting
(5) The cylinder-head has a longer life

The simplicity of this engine, in addition to its greater economy of operation, which at the same time results in a high degree of reliability with small wear and tear, indicates that automotive Diesel engines are possible, even compared with the present heavy-duty types of gasoline engine, the weight and the space required being about equal. The S.A.E. standards can be applied to it to practically the same extent. There seems to be no reason that this engine cannot be applied in many instances in the automotive field, with resulting benefit from its economy, conservation of the supply of gasoline, and reduction of the fire risk.

"Rationalization" in Germany

GERMANY has made tremendous progress industrially, and against heavy handicaps. She is, however, hampered by conditions that make further progress difficult and slow. She is putting forth great effort; and it is making her industrially strong. Eventually, she will play an important part in the world's commercial affairs. She is adaptable and fits herself perfectly into the conditions and requirements of modern industrialism.

For us in the United States the lesson seems to be this: Just now the competition of Germany will not have serious concern for the American people at large; but as our need for foreign markets grows and Germany's handicaps are reduced, German competition will be of deep concern to us. Let it not be looked forward to as commercial or industrial warfare. It is but the competition that we as Americans expect among ourselves; to the most intelligent and the most efficient shall go the reward; so too in the future competition in foreign trade. Germany will be a worthy rival; the tools of competition will be the research laboratory, studies in waste reduction, researches to discover new methods and new products, and, finally, hard and intelligent work. We are stimulating Germany now to high endeavor in engineering enterprise and industrial management. She will, in turn, stimulate us. Our future position as against Germany will depend on our technical ability and commercial alertness.

The word "rationalization," old in philosophical discussions, is newly applied in Germany to denote the many methods by which production costs can be lowered. It includes standardization, simplification of varieties, waste reduction, scientific management, and the replacement of hand labor by machinery, as well as the consolidation of corporations with a view of securing plant specialization, the closing of uneconomic production units, reduction of overhead, and effecting economy in selling.

Out of this consolidation era are doubtless coming great corporations, that will play a large part in the German industrialism and foreign trade of the near future. Germany, it is commonly said, has too many small corporations. Present conditions are forcing them together.

An additional noteworthy feature is propaganda to secure widespread use of the standards and practices agreed upon. News items, bulletins, pamphlets, handbooks of practice, exhibits of standards and good practice that can be sent to expositions, industrial conventions, chambers of commerce meetings and schools, films and statistical publications are included.

Probably the most important institution engaged in this rationalization enterprise is the Deutscher Normenausschuss, or German Standardization Committee, conducted under the direction of Dr. Hellmich. It is a child of the great German engineering society, the Verein Deutscher Ingenieure, and dates back to war times, to 1917. Its first name was Standardization Committee of German Industry, but its work has broadened so much that the reference to industry was dropped last year. The Ausschuss itself is a coordinating body largely, yet so extensive is its work that there are fifty people in its office in Berlin. The detailed technical work is done by committees in the various industries and these have no less than twenty established offices for handling their work. It is estimated that the total annual expenditure for this standardization work runs to 300,000,000 marks.

To Jan. 1, 1927, approval has been given to 1950 standards, embracing those of general application, such as for papers, screws, rivets, pipe threads, pipe, and the like, and standards covering specific fields. Some of the fields are welding, building materials and building parts, such as door and window sash, mining equipment, railroad cars and locomotives, electrical equipment, steam boilers, foundry equipment, wood-working machinery, refrigerating machines, automobiles, farm machinery, machine tools, ship building, typewriters, textiles and textile machinery.

Personal inquiry in different parts of the Reich have convinced me that the standardization work is well-known, highly regarded and supported not only by the engineers but by the executives of industry as well. Further, a good beginning has been made in international standardization on the Continent, and there are half a dozen groups of general standards that have the approval of from six to a dozen national standardizing bodies.—E. J. Mehren, vice-president, McGraw-Hill Publishing Co., Inc.

High-Speed Diesel Engines

By O. D. Treiber[1]

Annual Meeting Paper — *Illustrated with* Drawings and Charts

Of the various types of Diesel engine, that operating with solid injection of the fuel is now gaining undisputed favor, asserts the author. Most engines of this type operate on a dual or mixed cycle, that is, a combination Otto-Diesel cycle. A study has been made by the author to determine the efficiencies and mean effective pressures when the Otto and the Diesel cycles are combined in varying percentages, that is, when varying quantities of fuel are burned at constant volume and the remainder is burned at constant pressure.

Improvement in thermal efficiency was obtained up to the point at which 30 per cent of the fuel was burned at constant volume; beyond this point the thermal efficiency and mean indicated pressure fell off.

The development of Diesel engines is outlined, methods by which the weight has been reduced are discussed, and a description is given, illustrated with cross-sectional drawings, polar diagrams of the stresses on the crankpin and the main bearings, and curves of the valve characteristics, of a 16 x 16-in. 12-cylinder Diesel engine, running at 700 r.p.m.

The economy of Diesel engines has directed considerable thought toward the use of the Diesel principle in automobile engines. I am frequently asked when we expect to have Diesel engines in automobiles. This is a question which cannot be answered entirely by the Diesel engineer. It is easy to calculate the enormous National economic value of "dieselized" automobiles, but a further detailed study of the situation does not seem so encouraging. The Diesel principle will, nevertheless, be approached by designers of carbureting engines, and carbureting engines will be approached by Diesel engineers, so that ultimately an engine will be produced that will meet the public demands for comfort, reliability, flexibility, low first-cost, durability and, perhaps last of all, fuel economy.

The principle used in Diesel engines is becoming generally recognized as the ignition of fuel by the heat of compression in internal-combustion engines.

In the Diesel field a battle has been waged between the advocates of air injection and solid injection, and of self-ignition and semi-Diesel or semi-self-ignition of both air and solid injections. The systems all have served well, but I believe I am safe in saying that air injection and solid injection have held the limelight for some years, with solid injection now gaining undisputed favor in every field. The Diesel cycle has been well established as a constant-pressure cycle, as compared with the constant-volume, or Otto, cycle.

Most solid-injection Diesel engines operate on a dual or mixed cycle, that is, a combination Otto-Diesel cycle; and, of late, air-injection engines have been built for a similar dual cycle. I have made a study of this subject to determine the efficiencies and mean effective pressures when varying percentages of the Otto and of the Diesel cycles are used; in other words, when varying quantities of fuel are burned at constant volume and the remainder is burned at constant pressure. H. A. Huebotter assisted me in this analysis. We obtained a marked improvement in thermal efficiency by carrying the dual cycle up to a certain point, but found a falling-off in thermal efficiency and mean indicated pressure when more than 30 per cent of the fuel was burned at constant volume.

In actual practice the dual cycle can be carried to a point that, within reasonable constructional limits, will show fuel economy of about 0.35 lb. per b.hp-hr., which accounts for the tendency of air-injection engines toward the dual cycle.

Diesel engines were first made to burn coal-dust, the compression-pressure being about 900 lb. per sq. in. Later, the perfecting of air injection brought the compression-pressure down to 500 lb. per sq. in., and now certain types of solid-injection Diesels start from a cold condition with the compression-pressure at 325 lb. per sq. in. It is interesting to note that the compression-pressure of carbureting engines has been gradually raised. Diesels and carbureting engines, though radically different in type, are gradually approaching each other. Furthermore, carburetion has been improved to such an extent that the higher grades of fuel-oil necessary for some Diesel oil-engines at present on the market can be, and are being, used in carbureting engines with electric ignition and with marvelous economy. These developments naturally militate against the development of self-ignition Diesel engines.

The Diesel engine, as originally developed, was very large and heavy, and followed the generally recognized practice in the art of building large marine-engines, in which slow speed was necessary for propeller efficiency. The marine field for years offered the only Diesel-engine market; in fact, if it were not for marine business, there would be little or no activity in the building of Diesel engines in America today.

For years Diesels have been built that weigh from 175 to 500 lb. per hp. Slow speed was the rule. No market for fast-running engines existed. Attempts were made from time to time to develop higher speed and obtain lighter weight, particularly in small engines, but what little success was achieved was quickly discounted by the further development of carbureting

[1] M.S.A.E.—President, chief engineer, Treiber Diesel Engine Corporation, Camden, N. J.

engines using electric ignition. The whole world was organized to provide a carbureting fuel-oil at every turn of the road, chemists introduced the cracking process to produce more carbureting fuel from the crude, and now synthetic fuels doped for terrifically high compressions and using electric ignition are approaching Diesel-engine economy very closely on a weight-per-horsepower basis to the order of 0.5 to 0.4 lb. of fuel per b.hp-hr. Furthermore, the world has been organized to produce carbureting engines at very low first-cost and to service them, a general knowledge of their peculiarities has been increasing, and supplies of spare parts are well distributed throughout the Country. When we shall see Diesel engines under the hoods larger bearings, larger journals and crankpins, and have required heavier crankshafts and crank webs, all of which militated against higher speeds.

New Metal Alloys Aid Weight Reduction

A new era in Diesel engineering has arrived. Engineers are taking advantage of the progress made in the carbureting engines used in automobiles and airplanes and are using the new metal alloys now available. It is natural, therefore, that progress should be expected in reducing the weight of the larger engines, insofar as the market will absorb the product and provide opportunities for further advance.

Fig. 1 shows a 3000-hp. engine weighing 58,000 lb.

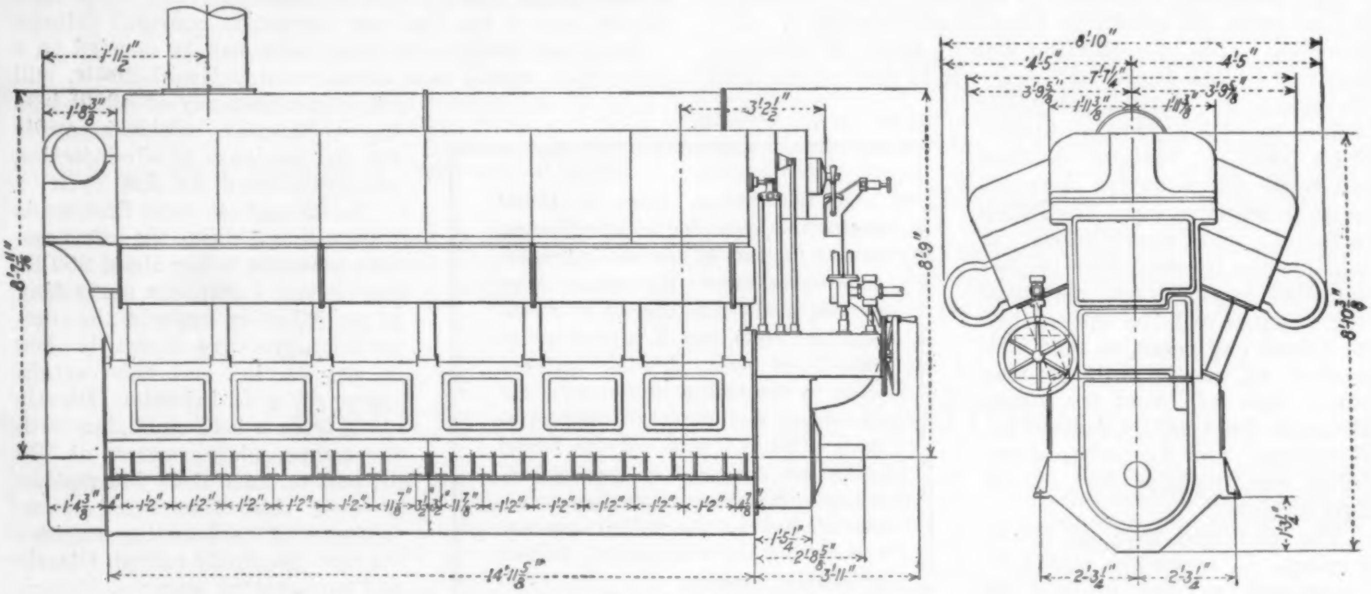


Fig. 1—Elevation of 3000-Hp. Diesel Engine

This Engine Weighs 58,000 Lb., Has Twelve 16 x 16-In. Cylinders, and Is Designed To Run at 700 R.P.M.

of automobiles depends, I believe, on how much longer carbureting engines and fuel-oils will continue to be improved and revamped.

Mechanics of the Diesel Engine

The mechanics of a high-speed Diesel engine is exactly the same as that of a carbureting engine. A Diesel engine using the Otto-Diesel cycle must be somewhat heavier than a carbureting engine, however, on account of the higher cylinder-pressures, which are about 350 lb. per sq. in. compression-pressure, and 750 lb. per sq. in. maximum pressure, at full load. Pressures of 1850 lb. per sq. in. may be expected with fouled spray-nozzles, which must find relief or will rupture unless the parts are heavy enough to withstand such pressures. Most Diesel engines are started with compressed air, and sometimes the fouling of the air starting-mechanism has caused supercharging to several atmospheres. When this has combined with fouled nozzles or with free oil in the cylinder, which often results when starting a cold engine, disastrous ruptures have occurred.

As cast iron has been the metal principally used for Diesel engines in years gone by, both the framing and the reciprocating parts have been very heavy. A bearing construction has been used that has been generally considered satisfactory for slow-speed steam-engines. The failures that have resulted have brought forth

This engine has been built from my design by the Treiber Diesel Engine Corporation, of Camden, N. J. It has twelve 16 x 16-in. cylinders and is designed to run at 700 r.p.m.

The mechanics of this engine is the same as that of any automotive engine. Fig. 2 shows polar diagrams of the stresses on the crankpin and the main bearings. It is interesting to note that the gas pressures form no part of the bearing pressures but, instead, serve to reduce them. Fig. 3 shows the valve characteristics, Fig. 4, the end view, and Fig. 5, the cross-section of the engine.

This particular engine is the direct-reversible type for marine service. It contains no cast iron. The framing is of steel. The liners are of forged steel and have aluminum-alloy heads. Oil-cooled aluminum pistons are used. Every moving part is enclosed and force-feed lubrication is used for every bearing and wearing-surface. The controls are arranged to start, stop, reverse and accelerate with one motion of the wheel shown at the end of the engine. Two emergency levers and an oil-pressure regulator are provided. Regulation of the cylinder powers one with another is accomplished by the use of a pyrometer and adjusting-screws on the top of the covers.

Getting back to our topic, it has been pointed out that Diesel engines work with higher gas-pressures than do carbureting engines, having terrifically high

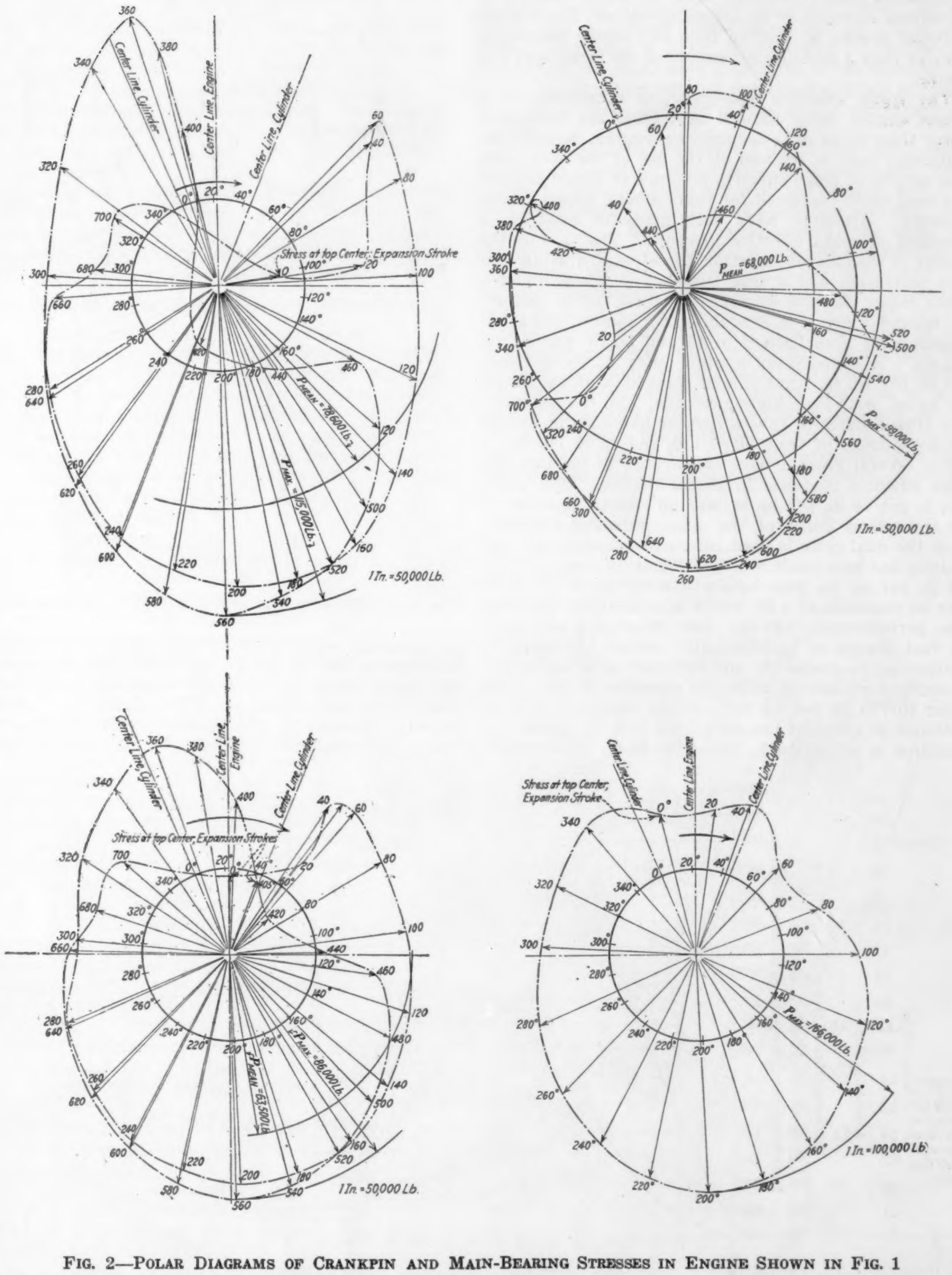


FIG. 2—POLAR DIAGRAMS OF CRANKPIN AND MAIN-BEARING STRESSES IN ENGINE SHOWN IN FIG. 1

The Diagram at the Upper Left, of Crankpin Stresses, Shows the Magnitude and Direction of the Forces with Respect to the Engine Axis. In the Diagram at the Upper Right, of Stresses on the Intermediate Bearing, the Maximum Pressure Is 99,000 Lb. and the Mean Pressure Is 68,000 Lb. That at Lower Left, of Stresses on the Main Bearing, Shows that the Maximum Pressure Is 86,000 Lb. and the Mean Pressure Is 63,500 Lb. In That at the Lower Right, of Load on Center Main Bearing, the Maximum Pressure Is 166,000 Lb. and the Mean Pressure Is 124,400 Lb.

preignition-pressures which must be taken care of by additional strength or by unloading-valves. These make a Diesel engine of a given bore and stroke inherently heavier than a carbureting engine of the same bore and stroke.

The mean effective gas-pressures obtainable in a Diesel engine using natural aspiration are inherently lower than those of a carbureting engine, because the expansion ratio is reduced by the use of the dual cycle. The subject of mean effective pressure in Diesel engines has been much contested for years among Diesel-engine builders. Attempts have been made to establish a standard of mean effective pressure. The fact of the matter is that an air-injection Diesel engine using natural aspiration and a true Diesel-cycle has a limiting brake mean effective pressure of about 80 lb. per sq. in., beyond which it is difficult to go. Some of the semi-Diesels have been limited to 45 and 50 lb. per sq. in. b.m.e.p. A carbureting engine today easily develops 110 lb. per sq. in. b.m.e.p., and some as high as 140 lb. per sq in., with even higher records. So, the air-injection Diesel seems to have a further handicap in weight per horsepower of from 80 to 110, and up to 140 lb.

For several years I have endeavored to increase the mean effective pressure in Diesel engines. Ten years ago, to get 75 lb. per sq. in. was an effort. A study of the theoretical limits of the mean indicated pressure, when the dual cycle is used, offers encouragement. An analysis has been made with the following assumptions: 350 lb. per sq. in. gage adiabatic compression-pressure with an exponent of 1.35, which is comparable with engine performance; 100-per cent volumetric-efficiency, the fuel charge to be chemically correct for complete combustion, no excess air, and sufficient oil to be burned at constant volume to raise the pressure at top dead-center to 700 lb. per sq. in., and the combustion to be continued at constant pressure until it is complete; the expansion to be adiabatic, using the mean gas-constant

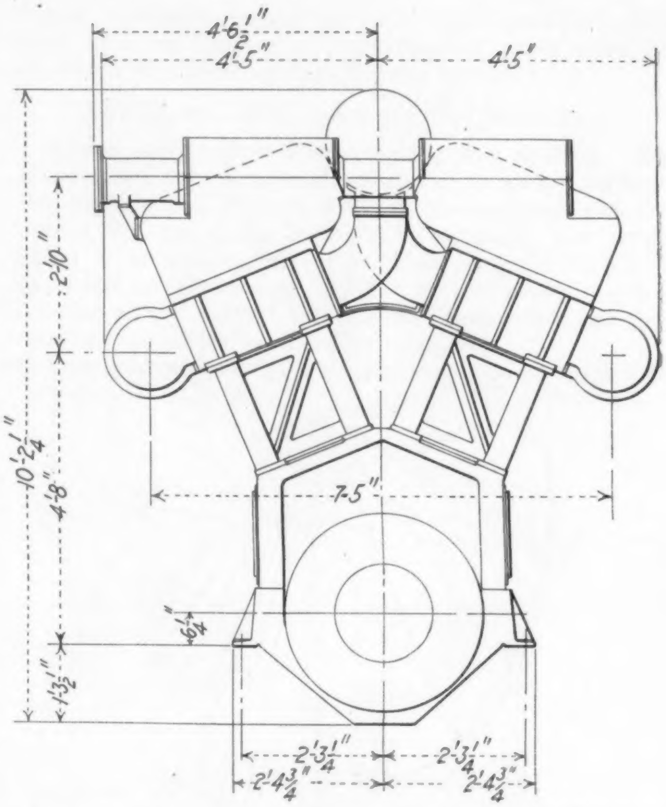


Fig. 4—Front-End Elevation of 3000-Hp. Diesel Engine

as exponent, which shows a theoretical mean indicated pressure of 245 lb. per sq. in., which we can approach but never reach, as there are losses due to radiation. dissociation and excess air. The theoretical indicated thermal efficiency is 45.6 per cent, corresponding to a fuel consumption of 0.308 lb. per i.hp-hr.; at 84-per

Fig. 3—Valve Characteristics of 3000-Hp. Diesel Engine

This Engine Has Twelve 16 x 16-In. Cylinders and Is Designed To Run at 700 R.P.M.

cent mechanical efficiency, the fuel consumption is 0.366 lb. per b.hp-hr.

If the above figure of 245 lb. for the theoretical limit of the mean indicated pressure is corrected for the losses we know to exist; namely, radiation, 20 per cent; excess of air, 10 per cent; volumetric-efficiency loss, 10 per cent, we must first correct for volumetric efficiency, namely, $245.00 \times 0.90 = 220.50$ lb. Then, correcting for the excess air required, we have $220.50 \times 0.90 = 198.45$ lb.

Many engineers, particularly European engineers, consider that 10-per cent excess of air is not enough. Carbureting engines, however, have probably exceeded this amount. By correcting the foregoing figure for losses by radiation, we have $198.45 \times 0.80 = 158.70$ lb.

High Pressures Necessitate Heavy Construction

Fig. 6 shows cards taken from engines that I have built having natural aspiration. It is interesting to note that the indicated pressure approaches the limits outlined. The one showing 160 lb. mean indicated pressure either had higher volumetric efficiency or used more than 90 per cent of the air. The exhaust was clear.

Correcting the theoretical indicated thermal efficiency of 45.6 per cent, which is equivalent to 0.308 lb. of fuel per i.hp-hr., and using fuel with the low heat-value of 18,500 B.t.u., we have the correction for radiation losses, 20 per cent, and for mechanical losses, 16 per cent, bringing the fuel consumption to 0.43 lb. per b.hp-hr.

In practice, as is to be expected, we find that the fuel consumption is reduced as the mean indicated pressure is reduced, and the amount of fuel burned at constant volume is maintained constant; in other words, by reducing the "lap" and maintaining the "lead" of the fuel spray. We have records of economy as low as 0.34 lb. per b.hp-hr., but the brake mean effective pressure was low, being about 80 lb. per sq. in.

Thus, we see that it is possible to obtain mean effective pressures equal to those of the carbureting engine, but the higher initial pressures will always make it necessary for the Diesel engine to be inherently heavier, with heavier reciprocating parts; and this again is a barrier to speed.

The speed is limited for two reasons; the first, mechanical, as noted, and the second, more important in small engines, by the time-lag of fuel ignition.

In a Diesel engine, a low volatile fuel-oil must be converted from a cold liquid-condition into a finely divided or atomized state and its temperature must be raised to a point at which the hydrocarbon atoms unite chemically with the oxygen in the air charge. This is the crux of many limitations. We do not know how to convert the fuel successfully into such a state before it is injected into the air charge. The greatest inherent difficulty in doing so is the decomposing of liquid fuel-oil while being converted into a gaseous state. If we find a way to convert heavy liquid fuel-oil into a gas without breaking it down, decomposing it, or freeing the carbon, we shall have a solution to the burning of oil in cylinders that will put the Diesel engines of today into the discard; but the nature of the oil cannot be changed.

Time is required to convert a liquid fuel into a finely divided or atomized state, raise its temperature sufficiently to unite it chemically with the oxygen, and produce combustion. This time is called the time-lag. The injection cannot be admitted too early in the cycle, for the fuel would enter the air at too low a temperature to produce ignition. By the time the heat from the compression became sufficient to ignite the hydrocarbons, so great a quantity of fuel would be in the air charge, which would be rising in temperature at the same time and rate, that, when the temperature was sufficient to produce a chemical union of the hydrocarbons and the oxygen, the action would be of such volume or quantity that the cylinder pressures would be raised above the practical limits. On the other hand, if the last of the fuel were admitted at a time favorable to the excessive rise in pressure as stated,

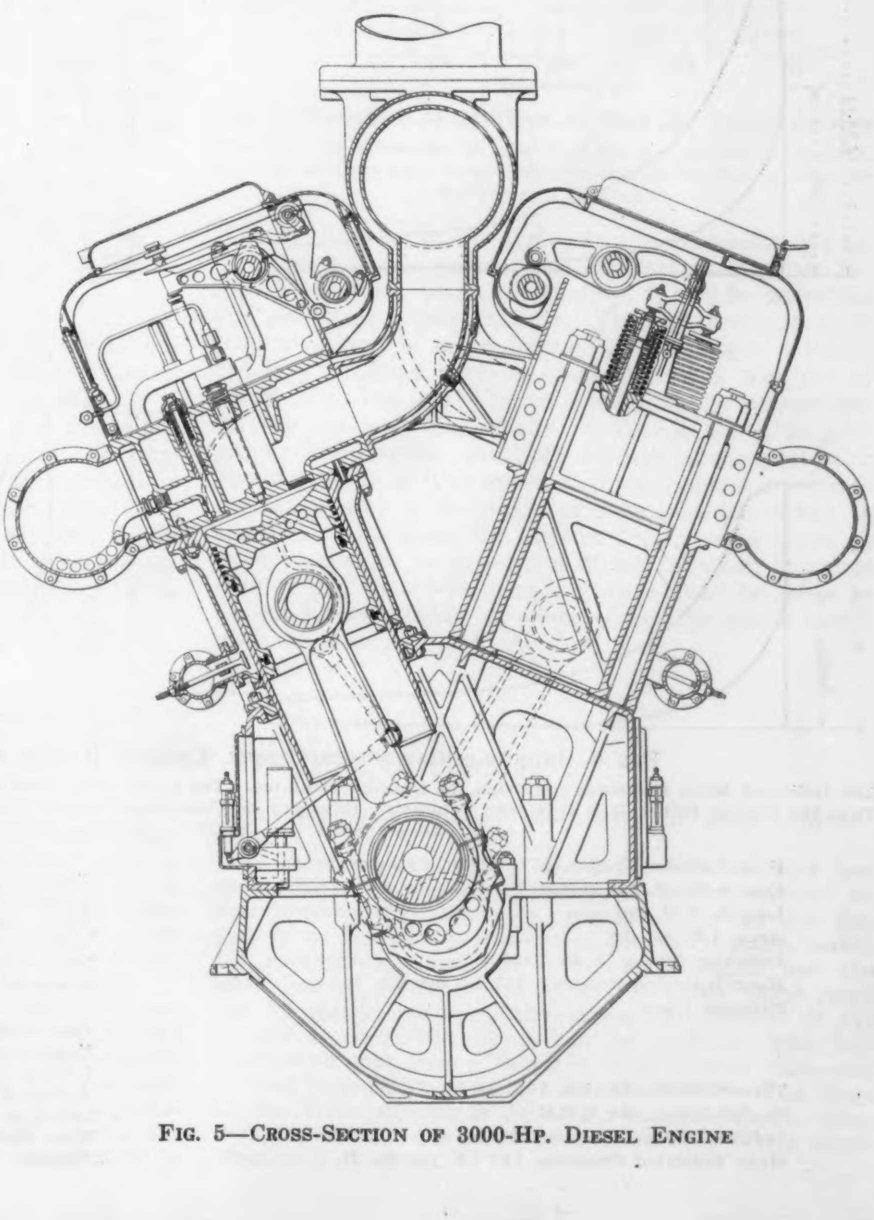


Fig. 5—Cross-Section of 3000-Hp. Diesel Engine

and if the engine were running at sufficient speed, the fuel would not have time to rise in temperature, become atomized, and unite with the oxygen until too late to be effective as a power-creating force.

Time-Lag a Serious Barrier

Dr. Kurt Neumann, of Germany, who has made some experiments along this line, finds that, with a compression pressure of 215 lb. per sq. in. and a spray that I consider coarse, the time-lag of ignition is 0.005 sec. I have calculated that the time-lag of some engines I have built is 0.0007 sec. Fig. 7 shows the time and degree-lag for various speeds. It can readily be seen that the time-lag is a serious barrier to high speed, and, if Dr. Neumann's results could not be improved upon, we could not hope to run Diesel engines at more than 200 to 300 r.p.m., regardless of the stroke. I believe that in time we shall improve the time-lag record I have made and shall raise the limit of speed. At present, however, because of time-lag, Diesel engines cannot be run as fast as carbureting engines; and this is a handicap in competing with high-speed carbureting engines on either a weight or a first-cost basis. Although Diesel engines have been run at 2000 r.p.m., their mean effective pressures and fuel consumptions were not very attractive; they did not compare more favorably in fuel consumption than do some present-day carbureting-engines, and they were limited to a brake mean effective pressure of about 70 lb. per sq. in.

Not only must the fuel in a Diesel engine be converted from a liquid into a gaseous state within the combustion-chamber, and be sprayed or atomized at a constant high velocity, but, particularly, it must be started and stopped at a high velocity to obtain the maximum results. The atomizing or spraying is done in two principal ways: (*a*) by direct injection into the combustion-chamber and (*b*) by injection into a subchamber or side combustion-chamber. The latter offers many alluring prospects for the designer, but is inherently a barrier in obtaining high mean effective pressure or good economy.

Possibilities of Direct Injection

Direct injection into the main combustion-chamber has three possibilities:

(1) The injection of a measured quantity of fuel by

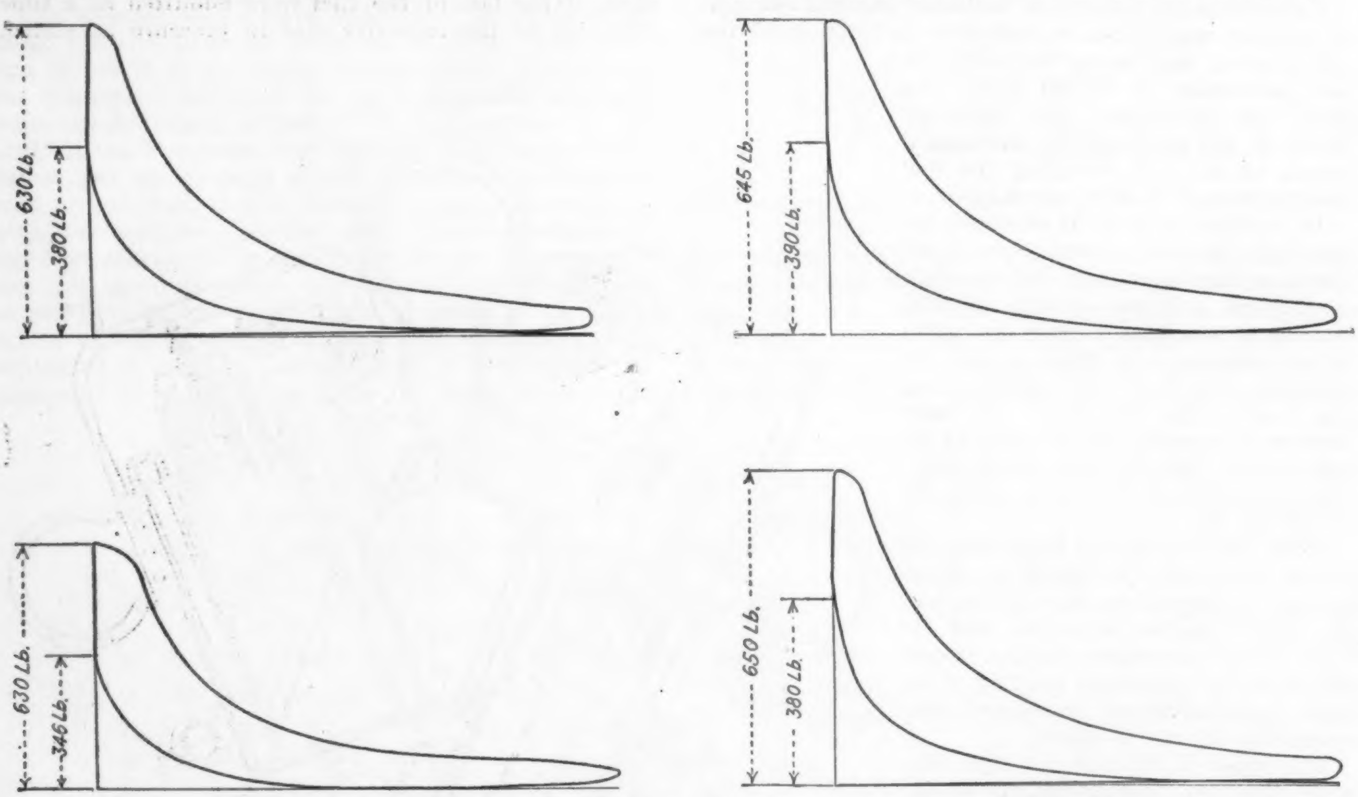


Fig. 6—Indicator Cards from Diesel Engines Having a Natural Aspiration

The Indicated Mean Pressures Approach the Limits Calculated. The Last Card, Showing 160 Lb. Mean Indicated Pressure, Indicates That the Engine Either Had a Higher Volumetric-Efficiency or Used More than 90 Per Cent of Air. The Data for the Diagrams Are Given Below in the Corresponding Positions

Four-Cylinder Engine, 15 x 22-In. Cylinders
Engine-Speed, 225 R.P.M.
Length, 2.83 In.
Area, 1.08 Sq. In.
Indicator Spring, 1 In. = 360 Lb.
Mean Indicated Pressure, 137 Lb. per Sq. In.
Exhaust, Clear

Four-Cylinder Engine, 15 x 22-In. Cylinders
Engine-Speed, 225 R.P.M.; Horsepower, 670
Length, 2.87 In.
Area, 1.20 Sq. In.
Indicator Spring, 1 In. = 360 Lb.
Mean Indicated Pressure, 150 Lb. per Sq. In.
Exhaust, Clear

Three-Cylinder Engine, 10 x 14-In. Cylinders
Engine-Speed, 280 R.P.M.
Indicator Spring, 1 In. = 420 Lb.
Mean Indicated Pressure, 140 Lb. per Sq. In.

Four-Cylinder Engine, 15 x 22-In. Cylinders
Engine-Speed, 225 R.P.M.
Length, 2.87 In.
Area, 1.20 Sq. In.
Indicator Spring, 1 In. = 360 Lb.
Mean Indicated Pressure, 160 Lb. per Sq. In.
Exhaust, Clear

a jerk, or by a timed plunger-pump, through one or more orifices

The impossibility of setting a body in motion instantly and bringing it to rest instantly militates against this method in a high-speed engine. The oil spray must start at and maintain a high velocity throughout the charge and must be cut off instantly from a high velocity. The timed pump does not lend itself favorably to these requirements. Fair results have been attained, however, and if a spring-loaded valve-controlled spray-nozzle is used, this method may become more popular.

(2) Automatic injection, such as that of the Hvid system

This has some limitations that offer little encouragement for high speed. A modified automatic system,[2] developed by C. L. Cummins, utilizes a plunger to dispel the prepared charge of fuel. This system deserves credit, for it raises the temperature of the fuel-oil before injection, and the usual difficulty found in the automatic Hvid system, namely, the decomposition of the fuel that leaves obstructing carbon deposits in the spray orifices, has not, to my knowledge, been experienced. The element exists, however, of putting a body in motion instantly and of bringing it to rest instantly by the use of the timed plunger in driving the fuel out of the cup; and this fundamental condition seems to me to be a barrier in obtaining the maximum fuel-economy and mean effective pressure. I know, however, that the Cummins principle has been giving very good service.

(3) In the constant-pressure system, the fuel-oil is maintained at a constant pressure above the spray-nozzle orifices at all times and a mechanically operated valve, seating in the nozzle above the orifices, controls the fuel-flow to the combustion chamber

High starting-velocity and a quick cut-off can be obtained by this method, which assures the maximum efficiency of this important function. As the oil is maintained at a constant high pressure just above the spray orifices, it can be brought to a very high temperature before being admitted into the combustion chamber without being decomposed. This aids it in rapidly atomizing and uniting with the oxygen. Space is required to convert the liquid fuel into a gaseous state and to raise its temperature, as already mentioned.

[2] See THE JOURNAL, October, 1927, p. 388.

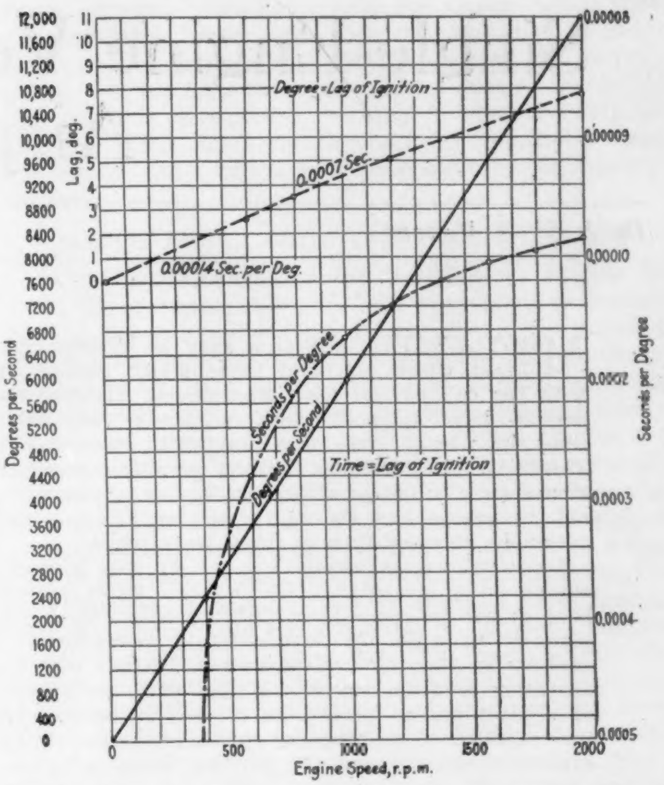


FIG. 7—TIME-LAG OF IGNITION OF 3000-HP. DIESEL-ENGINE

Time-Lag Is a Serious Barrier to High Speed and at Present, Because of Time-Lag, Diesel Engines Cannot Be Run as Fast as Carbureting Engines

It must come out of the orifice at a terrific velocity and, if it touches any part of the combustion-chamber before it has been completely gasified, it will be deposited and produce a smoky exhaust. This space requirement for conversion is not a barrier in the larger engines, but it is in small engines, since the oil is required to travel from 1½ to 2½ in. to accomplish the conversion. As the spray is necessarily of funnel shape to give proper atomization, multiple orifices are superior to single orifices in high-speed engines, because the time-lag is greater with single orifices and the spray is coarser. With these limitations, little chance seems to exist to deviate from central direct injection in cylinders of less than 5-in. bore, and care must be taken to design for maximum turbulence from the piston movement to coincide with the fuel feed.

Relief of Traffic Strangulation

MATTER in the wrong place is dirt, but when moved to the requisite place is wealth. Road traffic today, as in the past, is concerned with changing the place of matter mainly with this wealth-producing objective; in doing so it employs labor and capital, but it also takes time. The quicker it goes, the less time it takes, and, for any given amount of transport equipment, the more wealth it produces per day and the less it congests the road.

No experiment has been made in any country to determine at what traffic-density strangulation occurs, and consequently no legislature has yet enforced the economical means for preventing it and retaining the maximum flow. Increasing the tonnage of the traffic unit is a palliative limited by axle loads, until we further develop the caterpillar, and leaves us still in need of regulations to secure the maximum safe flow, even of these improved units.

To increase speed safely up to the road capacity has no economic drawbacks. To limit the speed, whether by overcrowding, by restriction, regulation, or by the disorderly or the slow movement of the traffic units, makes for congestions which are immensely wasteful and the birthplace of accidents. If at any congested place speed can be safely increased, any transportation that is approaching congestion there can be achieved with less vehicles on that place; therefore, with a freer road—and a freer road reacts to make such speeds safer. The hinge of the traffic problem is the safe increase of speed.—Mervyn O'Gorman, in a paper presented at the World Motor Transport Congress.

Single-Engine Versus Multi-Engine Airplanes

By A. H. G. Fokker[1]

Aeronautic Meeting Paper

MULTI-ENGINE airplanes may be divided into those which can and those which cannot fly with the full normal load after one or more of the engines have stopped. Until within a very short time the former class was practically non-existent. The latter class includes military airplanes in which it is desired to obtain a fuselage having a nose without an engine and those in which sufficient power cannot be obtained from a single powerplant.

Some two-engine planes that can fly with a single engine on a test flight fail to do so after having been in use for some time. Ability of a two-engine plane to fly with one engine usually necessitates a sacrifice in the pay-load to such an extent that its operation is uneconomical. Flying with one engine of a multi-engine plane idle is difficult because of the reduction of the propeller speeds of the remaining engine or engines and the turning forces involved. These disadvantages can be overcome only by applying greater forces through the controlling surfaces, which, in turn, entails the additional disadvantage of increased head-resistance. The solution of the propeller problem lies in the use of adjustable-pitch propellers, which, however, add further undesirable complications.

Although a multi-engine plane provides insurance against forced landings, this insurance is gained only at the cost of increased fuel-consumption and greater head-resistance. In simplicity, efficiency, economy of running and initial cost, the advantages are said to be all on the side of the single-engine plane. If multi-engine planes are considered desirable because of their insurance of reliability, the minimum number of engines used should be three; and in few cases is such insurance worthwhile except in large and expensive craft.

THE facts that different kinds of multi-engine airplanes have been developed for a long time, although mostly for military purposes, and that during the last few years such airplanes have been in use for commercial operation, have frequently led the public to form the opinion that a multi-engine craft is safer than a single-engine craft. On many European airlines many multi-engine airplanes have been and are still in operation in which the increased horsepower is utilized for no other reason than to increase their carrying-capacity, rather than to obtain safety through their ability to fly on the remaining engine or engines in the event of the failure of one powerplant. Multi-engine airplanes, therefore, can be divided into two classes:

(1) Those able to continue flight with the full normal load after one or more of the engines have stopped

(2) Those not able to continue flight with the full normal load after one or more of the engines have stopped

Class (2) can be subdivided according to the reasons for which more than one engine is used; namely,

(1) Those used for military purposes, as for bombing or similar special purposes, to obtain a fuselage having a nose without an engine

(2) Those in which the engine power required by the design and by the purpose for which the airplane is built is not available in one powerplant, two or more small engines being used instead of one large one

It is obvious that in Class (2) the actual risk of a forced landing is multiplied by the number of powerplants used, and therefore the reliability decreases with the number of engines.

Until a short time ago, multi-engine airplanes in Class (1) did not exist. Even now I am risking protest from several designers by stating that two-engine planes in Class (1) practically do not exist. I know of many newly designed planes that have demonstrated their ability to fly with one engine on their first test flight; but an enormous difference exists between the demonstration of a new well-tuned plane and the same type later on when in production, really fully equipped, and after all the reinforcements, improvements and additions, which never fail to be made after the first plane has been demonstrated, have been incorporated into it. Certainly, after such planes have been in service for some time, the efficiency drops because of the wear and tear on the engines and because the finish of the ship and the propellers have likewise suffered from the weather.

The ability of a two-engine airplane to fly on one engine is proved only if such a craft is able not only to fly for a short time on one engine, but is able to develop sufficient reserve to run on one engine for at least a few hours without overheating or overstraining the engine. I have built and have demonstrated several types of two-engine airplanes, but to enable them to fly for a long period under the conditions mentioned would necessitate a reduction of the pay-load to such an extent that the airplane could not be operated economically. Two-engine airplanes used for military purposes, when the excess load can be dropped at any time if it is necessary to continue on one engine, are an entirely different and reasonable proposal, because the carrying capacity can be utilized to limit; whereas the limit of the capacity of a smaller commercial plane, from which it is not feasible to drop the passengers or their luggage, or both, is dictated by the carrying capacity that can be developed with one engine while leaving sufficient reserve for safe flying and maneuvering. It is still very difficult to produce even three-engine planes that are really and honestly in Class (1) while carrying their normal full commercial load.

[1] M.S.A.E.—President, Fokker Aircraft Corporation; vice-president, Atlantic Aircraft Corporation, New York City.

Propeller Speed Less with a Dead Engine

The following is a review of a few of the inherent features that must be borne in mind and that present the difficulties to be encountered in designing and using aircraft that are able to continue safely with one engine dead. Many persons who have never analyzed the matter have the delusion that if one engine of a two-engine plane stops in flight, 50 per cent of the original horsepower is left for the purposes of flight; and, similarly, on a three-engine plane, two-thirds of the original power remains. Unfortunately, this is far from the truth; the facts greatly increase the disadvantages of the two-engine plane in this respect as compared with a three-engine plane. When one powerplant stops, the airplane slows down and the remaining propeller is not able to develop the same number of revolutions as when both the powerplants were driving the airplane at full speed. This applies also to the three-engine airplane.

To take a concrete example, without going into mathematics: If my trimotor plane has propellers that will turn at 1800 r.p.m. at 220 hp. at full speed with all three engines going, the remaining two propellers, if one of the three stops, will turn at only a little more than 1700 r.p.m. Therefore, we have the effect of a total of only 370 instead of 440 hp., as the failure of one of the three engines would lead us to believe. With a two-engine plane the situation is much worse. In a plane having 600 hp. available from two engines, not more than 40 per cent, or 240 hp., would be available from one engine after the other had stopped.

Turning Forces on Plane Present Problem

To this disadvantage of the two-engine plane a further and equally serious one must be added. I refer to planes of the usual type having outboard engines, as very few remarks apply to possible, but hitherto not developed, types having central engine-rooms from which multiple powerplants drive a single propeller. The turning forces applied to the airplane, after the failure of one outboard powerplant are naturally much greater in the two-engine airplane than in one having three engines.

To overcome these disadvantages, correspondingly greater forces must be applied by the controlling surfaces, of whatever design these may be or however they may be disposed, to keep the airplane on its straight path or to make a turn to the opposite direction. Such controlling forces are, so to speak, only the products of head resistance. The two-engine plane therefore suffers a greater increase in head resistance, due to these controlling forces, than does the three-engine plane and requires more power to keep it in the air. This means only that it consumes a greater percentage of the remaining but already reduced horsepower. This is proved by the fact that most designers of two-engine planes are expending considerable ingenuity on special control-surfaces, such as duplicate rudders, emergency rudders, and the like, arranged in positions where they will have the benefit of the slipstream of the remaining propeller and consequently will have a better controlling effect with less expenditure of head resistance. Such devices, however, have other disadvantages, such as increased head resistance at all speeds in normal use and, in the case of military planes, reduction of the field of fire to the rear and greatly increased vulnerability from the enemy's fire.

But the greatest factor in increasing the inefficiency of the airplane when flying with one engine idle is that the remaining horsepower is further absorbed in overcoming the resistance of the stopped engine and its propeller, which means that only a small part of the original available horsepower remains to keep the ship in the air. What this percentage is depends entirely upon the type of the airplane and the location of the missing engine.

Solution Lies in Adjustable-Pitch Propellers

In the arrangement of two powerplants in use on some flying boats, in which one powerplant is located behind the other, the disadvantage due to the turning forces when one engine stops is non-existent. However, the loss of efficiency of the propellers, with the resulting reduction in speed, and the increased head-resistance of the non-driven propeller and its engine, provide the same problem as that of any other two-engine airplane.

The entire solution of the propeller problem in multi-engine aircraft, no matter what arrangement of engines is used, lies in the use of propellers the pitch of which can be adjusted by the pilot. This is, however, a weighty complication, especially when the controls for adjusting the propellers must be connected to outboard engines from the central cockpit; but this may become the standard practice as soon as reliable adjustable-pitch propellers have been developed. I am skeptical, however, as the present propeller is a delicate device and is practically the only source of danger in flight, hence further complications are not desirable. This has led several users of three-engine planes to use large-pitch or large-diameter propellers which reduce the speed of all three engines 100 r.p.m., or even more, when all three engines are running. In that way they obtain a high cruising-speed and low gasoline-consumption. The disadvantage in a slower take-off with such propellers is minimized in the three-engine plane because, owing to the excess of power available, the take-off is fairly good anyway. They use such a combination of propellers satisfactorily for a long time and congratulate themselves on having reduced the average time between two terminals by 20 or 30 min. When one engine stops, however, the "piper must be paid," and it is found that the two remaining propellers do not turn fast enough to keep the airplane in the air if it is carrying its full load, or the engines become overheated in a very short time.

Single-Engine Plane Has Longer Range

The multi-engine principle must be considered as insurance against a forced landing due to the failure of one powerplant. This insurance, of course, cannot be obtained for nothing; it costs more in fuel consumption and in head resistance, if the insurance is to be good. Therefore, intrinsically, a single-engine ship having the same design and power, so far as possible, is bound to have a longer range. To use the Fokker F-VII again as an illustration, this trimotor plane, having three Wright Whirlwind engines and the large wing, has a range of about 4300 miles as compared with the same ship fitted with a single Pratt & Whitney Hornet or a Bristol Jupiter engine, which gives it a range of about 5500 miles.

In simplicity, efficiency, economy of running, and initial cost, the advantages are all on the side of the single-engine plane. The reliability is undoubtedly great. I have received some interesting figures from the Wright Aeronautical Corporation which show that,

with the Wright Whirlwind engine, 20 forced landings have occurred, only three of which were direct mechanical breakdowns, in a total of 1,750,000 miles flown, or 87,500 miles per forced-landing. This figure should be compared with similar figures in the automobile industry, where it is a very rare occurrence for a car to run one-half this distance without some failure, apart from lack of fuel or oil, that will stall it at the roadside.

The results of even such a single failure, however, especially in the case of a large expensive airplane, may very well be deplorable for every one concerned. Even the repairing of damaged aircraft is very seldom an attractive financial undertaking. These figures, therefore, prove only that the possibility that two engines out of three will fail in one flight is so small as to be negligible. To make this true, due precautions must be taken in the design of powerplant installations and sufficient thought must be exercised to install the fuel tanks, the pipe lines and the wiring so that a single failure that will cause all three engines to stop cannot occur.

It is my conclusion that, if multi-engine airplanes are selected to obtain the highest possible degree of safety against forced landings because of engine failure, the two-engine craft is uneconomical and undesirable. The minimum number of engines in multi-engine airplanes should be three, to give sufficient insurance, if such insurance is the main reason for using multi-engine craft. As in the case of all other insurance, it is the most worthwhile if the property to be insured is valuable. Therefore, the insurance of reliability, which is the insurance against crashes that is provided by the three-engine principle, is the most worthwhile, and, in many cases, is worthwhile only in large and expensive airplanes.

In view of the relatively higher operating-cost, I believe that it would not be worthwhile to bother about the three-engine principle in the smaller and relatively cheaper aircraft, as the amount of possible damage is less with a small machine than with a large heavy machine. The investment in large planes justifies the higher cost of insurance provided by the multi-engine principle more than does that in a low-priced airplane, in which the higher operating-cost of three powerplants would be out of proportion to the pay-load. This, of course, holds true so long as small airplane engines cannot be manufactured and sold at prices at present in vogue in the automobile industry.

THE DISCUSSION

I. I. SIKORSKY[2]:—For a long time I had lots to do with big multi-engine airplanes. I built a number of them with two, three, four, and some with five, engines. The five-engine plane was built in 1914, with four German engines and one French engine, and of course I had all sorts of trouble in 1914 in making the Germans work together with the French. I could not synchronize them, so I had to dismount them. Therefore, I have no particular sympathy for any one of these types of airplane, but believe that I would trace a slightly different line of usefulness of each of them.

I agree fully with Mr. Fokker that the single-engine airplane remains the most efficient type aerodynamically. I believe, however, that when a flight for several hours with full load is required with one engine dead, at least three or four engines will be necessary; but I believe that between these two extreme cases there is a considerable space that a reasonably built twin-engine airplane may well fill. For instance, on a trip from New York City to Washington or to Boston, or if it is necessary to fly 300 or 400 miles in any territory in the United States, in three-quarters of the cases do you not think there is a flying-field within 25 or 50 miles at all times? It is easy for a good modern twin-engine plane to fly that far with one engine dead and one working. This has been demonstrated many times with our old S-29 airplane. We have had all kinds of engine trouble and several times came back to the flying-field with a dead-stick propeller. The old twin-engine airplane did a considerable amount of flying, and the last time it could not maintain altitude on one engine when heavily loaded; still, it was able to fly on one engine sufficiently well to save the craft and protect the occupants.

When the flight is for 500 or 800 miles over sea or over several hundred miles of high mountains, two engines are not sufficient; three or more are needed. On the other hand, if the flight is made under ordinary conditions where one may expect to have landing-fields every 30 or 50 miles or so, two engines will give all the safety needed.

Of course, besides the kind of service, it is necessary also to distinguish between the types of airplane. I believe that for such service as will exist, for instance, between New York City and Boston or the City of Washington, or in the Great Lakes region, the twin-engine amphibian will give more actual safety than a three-engine landplane. A forced landing, which is the greatest danger, may be a result not only of engine failure but of bad weather. In this case, the ability of the amphibian to alight on any body of water, and the superior unobstructed visibility for the pilot of the twin-engine plane, give it distinct advantage.

I should say that every type of airplane, single-engine, twin-engine and with a larger number of engines, has its own field of action in which its use is advantageous. The twin-engine airplane in particular certainly will remain a very useful and popular type in both military and commercial aviation.

NUMBER OF CYLINDERS CONTROLS OVERHAUL COST

ARCHIBALD BLACK[3]:—I hope that Mr. Fokker has read one chapter in my book, Transport Aviation, in which I analyzed this point of two engines versus three engines mathematically and showed that any airplane designed to fly on one out of two engines has the performance, not of a commercial airplane, but of a military scout plane; that is, the commercial load must be sacrificed to gain assurance of safety. It must be remembered, of course, that the two-engine airplane has one important advantage over the single-engine craft; that is, it has a greatly increased gliding range if one engine is still running.

I think the point made by Mr. Fokker of the necessity of keeping the gasoline and ignition system independent

[2] President, Sikorsky Aero Engineering Corporation, New York City.

[3] M.S.A.E.—Consulting air-transport engineer, Garden City, N. Y.

is very important and might have been stressed more. If the gasoline systems are united so that a break at any point will shut down all three engines, we are back where we started.

With regard to the cost of engines and overhauls, I found, in my operating cost studies, that there was very little difference in cost due to size, except in the matter of parts replacement. The cost of overhauling an engine usually is governed, apart from that of design, by the number of cylinders. It costs about as much to take apart and reassemble a 9-cylinder engine of 200 hp. as a 9-cylinder engine of 500 hp. On the other hand, if one built a 16-cylinder engine of 200 hp., it would cost more to overhaul than the 9-cylinder engine of 500 hp. The number of cylinders is the chief item affecting the labor required to make an overhaul.

CLARENCE HANSCOM[4]:—I agree with Mr. Fokker as to the advantages of three engines, but I know from experience with a twin-engine plane which was not designed to fly on one engine and which did not do so on official tests, that it is possible for a twin-engine plane to fly with a reduced load. It is also feasible at present to dump gasoline in case of emergency, and it is obvious that a twin-engine plane can be built that will fly satisfactorily under these conditions on one engine. However, I believe that the future, certainly for the large commercial types, lies in the multiple powerplant located in a central engine-room where it can be taken care of. It seems to me that one of the vital problems before us at present is to develop such a powerplant.

Choice Depends on Conditions of Use

C. H. BIDDLECOMBE[5]:—The theory of three-engine versus single-engine airplanes is extraordinarily interesting, but I think practical use is the final criterion of the value of the two types. To compare a three-engine airplane and a single-engine airplane is like trying to compare the Leviathan with the Boston-to-New York City steamships. Whether one or three engines should be employed depends upon the service for which an airplane is wanted, particularly the kind of route over which it is to be operated. The three-engine plane has, I think, a certain measure of safety over the other at greater altitude. From personal experience I can assure you that engine trouble near the ground with the three-engine airplane is very nearly as bad as with the single-engine plane; there is very little to choose between the difficulties a pilot finds himself in just after taking off or below 500 ft. His hands are full in either case and, if a wing engine quits, the two remaining engines do not help a great deal owing to the turning movement that is set up by the wing engine that is still running. I found that to turn a three-engine airplane against an engine that is running while the other wing engine is dead, one must put the nose down very appreciably. If the ship has plenty of altitude, one can get the control Mr. Fokker spoke of by putting the nose down, but this cannot be done when an engine quits near the ground; so I think that, on the whole, there is not a great deal of difference for overland flying between the three-engine and the single-engine airplane from the safety point of view. Over the sea it is a different story.

Another point is that the three-engine airplane of today is much larger than the single-engine plane, requires much more landing distance and is much slower to answer its controls. The result is that, if a forced landing of the three-engine job is made necessary by the weather, it is hard to land this airplane in a small field. In actual operating conditions I found that one had about 79 forced landings for weather to two for engine trouble.

Difference in Operating Costs

A rather interesting point is the relative cost of running the three-engine and the single-engine craft. We found in practice that to fly a trimotor airplane on the Boston-to-New York City route cost just a little more than double as much per mile when it was operating and about three times as much when idle; that is, when it is out of commission for overhauling, change of engines and that sort of thing, three times the amount of standing charges are accumulative and cannot be escaped. That great difference in cost can be made up by much higher earnings provided the airplane is being operated over a route that will yield those earnings, but very few routes developed today have anywhere near a volume of traffic that is sufficient or ground organizations that are efficient enough to enable anyone to utilize the full potential earning capacity of the three-engine craft. Therefore, I think that, except for unusual conditions, such as routes on which a forced landing means absolute disaster, or where passengers are carried at night, the single-engine airplane carrying a pay-load of not less than 4 lb. per hp., or up to 1200 lb. including two to six passengers, is the type on which the American air-transport industry is going to be built up in the next 3 or 4 years.

J. OTTO SCHERER[6]:—Mr. Biddlecombe is comparing the three-engine airplane of about three times the size with the single-engine craft. The comparison should be drawn between airplanes of perhaps the same capacity or the same unit cost. This would be the case only if two machines, such as the Fokker F-VII-a Jupiter and the F-VII-a-3 M, which are practically identical except for the powerplant, were compared. With two such similar craft, it would be fair to attribute all differences in performance, cost of operation, and the like, directly to the type of powerplant. But it is not fair to make a direct comparison of the cost of operation of a single-engine airplane of 220 hp. carrying a pay-load of 800 to 1000 lb. with a trimotor plane of 660 hp. carrying a pay-load of 2500 to 3000 lb.

Coordinated Crew for Large Ships

OSCAR A. ROSS[7]:—Referring to Mr. Biddlecombe's remarks about the difficulties of maneuvering multi-engine airplanes, I judge that the three-engine plane to which he referred was substantially of three times the weight of a single-engine plane and, therefore, in all other measures comprised a multiple of three. Obviously, a larger airplane is more difficult to maneuver than a smaller one. This in no way prevents the same effectiveness in landing. With regard to the piloting of large airplanes, whether single or multi-engine, the following suggestion is offered. Instead of assigning one pilot for all flight controls, I recommend the employment of a captain or master of all controls to issue scheduled or emergency orders, a keelsman who controls the keel flight only, a courseman who maintains the course of flight and also controls banking, and a

[4] M.S.A.E.—Consulting aeronautical engineer, Lake Arrowhead, Denville, N. J.

[5] Aeronautical transportation engineer, New York City.

[6] Jun. S.A.E.—Chief engineer, Junkers Corporation of America, New York City.

[7] M.S.A.E.—Consulting engineer, New York City.

brakeman who controls the braking devices of the landing gear incidental to the airplane.

I wish to convey the necessity of coordination of a group of men each of whom is highly trained for a specialized duty. As an example of accomplishment thereby, attention is called to the successful anti-aircraft-attack demonstrations recently staged at the Aberdeen Proving Ground when 10 or 12 men were employed in maneuvering the sighting instruments that automatically aimed the anti-aircraft guns. Each man had a specific task and performed it accurately. The combined efforts of all the men resulted in sufficiently accurate aim to pierce the moving target repeatedly.

It is not believed that one pilot can exercise successfully at one time three or perhaps more chains of thought which it is obvious are required in the event of an emergency landing.

Multiple-Engine Drive-Unit Available

E. T. Jones[8]:—I have had occasion to think at one time or another about the type of construction in which several engines are placed in the fuselage and connected to a single propeller, equipped with clutches and gears so that any engine can be disconnected for the making of repairs or an engine can be carried in reserve that can be thrown-in in case one engine fails. This scheme, it seems to be, is open to the basic difficulty that all of the power is brought to one point where failure will incapacitate all the engines at once. For instance, if there is but one propeller-shaft, a tooth broken out of the propeller gear means that not one engine but all the engines stop.

Another consideration is that, regardless of how much skill one brings to bear on a design of this type, he cannot make that transmission without adding weight. I think it is a very big question whether the reduced head-resistance secured by that type of construction will overbalance the weight that is added. From these two points of view, the scheme is by no means so attractive as it seems at first.

While at McCook Field I had the job of supervising the design, construction and endurance test of a unit of this type which completed its 50-hr. test without a failure or forced stop of any kind. That entire unit weighs less than ½ lb. per hp. and has been available for about 3 years, yet nobody has seemed to care to design an airplane around it. I am sure that if anyone would like to do so he would have very little difficulty in making arrangements with the Government to borrow the equipment; personally I should like to see it tested.

[8] M.S.A.E.—Chief powerplant engineer, Wright Aeronautical Corporation, Paterson, N. J.

[9] M.S.A.E.—Assistant secretary of the Navy for aeronautics, Navy Department, City of Washington.

Chairman E. P. Warner[9]:—It is significant that the type of powerplant of which Mr. Jones spoke, which has attractions in theory and which has been given consideration in the laboratory to the extent of making laboratory tests, was tried out more or less extensively in practice about 10 or 11 years ago and has commanded very little favorable notice from airplane designers since that time.

Safety Depends on Flying Altitude

A. H. G. Fokker:—I am building all types of airplane and have customers for every type. I agree with everything that Mr. Sikorsky said about the two-engine airplane, but I think the question is how low the pilots are going to fly. It is very difficult to get the commercial pilot to fly high; on many days it is impossible for him to do so. That means he has to fly 200 or 300 ft. high over a long stretch where normally he can find a landing-field in 2, 3 or 10 miles; but, in practice, if one of his engines quits, very often he cannot make a safe landing in spite of a good light he can make; so the theoretical safety of the two-engine plane comes down to the real practice. The Department of Commerce, then, should make a regulation that a two-engine airplane to carry a certain number of passengers may fly only at a certain altitude; but the results would be that on many days the pilot simply could not fly. With amphibian-airplane flying, the question is different. The only disadvantage of the multi-engine airplane is that one engine is always more economical and not so heavy as two engines of half the horsepower.

Whether the three-engine airplane is as difficult to handle as any other, directly after the start, depends on the condition of the craft and many other circumstances. I have many pilots who have flown and taken-off fully loaded three-engine airplanes on two engines. I have done it myself and have seen it done by pilots. I am ready at any time to demonstrate the start on two engines without the third engine running at all.

I think it is not proved that two engines cannot run at full capacity; the gasoline flow might not have been sufficient and it is difficult to prove such facts afterward. But I cannot agree with the statement that our three-engine airplanes, when fitted with the proper propellers and not overloaded and when supplied with the proper quantity of gasoline, cannot be flown or taken off if one engine quits at any time. The landing of a three-engine airplane is always possible in any place where any other aircraft can be landed. This has been proved by many Army and other pilots; it is proved by pilots from the Colonial Air Transport itself. I have flown over Florida when we had to look for a place to land, and if we saw a "Jenny" on the ground we would say: "We have a place where we can land," and we did it.

Some Aspects of Supercharging for Sea-Level Conditions

By C. Fayette Taylor[1] and L. Morgan Porter[2]

Annual Meeting Paper — *Illustrated with* Drawing and Charts

Using an internal-combustion engine with variable expansion-ratio, the authors have made a series of tests at normal atmospheric-pressure with a supercharger to secure increased power output.

These tests indicate the results in horsepower and efficiency that can be attained in automobile engines by independently varying the expansion ratio and the total compression-ratio.

The theoretical horsepower and efficiency were computed for the conditions of the tests for purposes of comparison.

A series of curves shows graphically the results of variations in the different factors and compares the test results with the calculated values.

One of the possible uses of supercharging is to secure increased output at sea level from an internal-combustion engine of a given size. This application is particularly important where engine displacement is limited, as in automobile racing, and may become of importance in certain types of automobile, and in aircraft where sea-level power-output greater than the normal is required temporarily, for the take-off or for other purposes.

It is obvious that the true compression-ratio of the supercharged engine is a function of both the compression ratio of the supercharger and the so-called compression-ratio of the engine itself, but that the expansion ratio is the same as if the engine were not supercharged. Using these terms in their true sense, the compression ratio of the supercharged engine may be changed by changing the supercharger delivery pressure while the expansion ratio is fixed by the cylinder and piston design, at least in the normal type of engine.

In a given engine, either supercharged or not, the maximum allowable explosion-pressure usually is limited by considerations of design and the detonation characteristics of the fuel used. It is therefore of interest to investigate the possibility of obtaining increased power from the supercharged engine without exceeding a given explosion-pressure. Since compression ratio is the chief factor controlling the explosion pressure, it is evident that the over-all compression-ratio must not be increased, but it seems possible to achieve a gain in power by increasing the compression ratio of the supercharger and decreasing that of the cylinder. This reduces the expansion ratio and hence the indicated thermal-efficiency, but, unless carried to an extreme, will increase the indicated mean effective pressure, since, within limits, the greater total volume of the cylinder and the higher charging-pressure increase the charge weight more than enough to offset the loss in efficiency.

The effect of such a procedure on the brake horsepower and brake thermal-efficiency will depend on the particular values chosen for compression and expansion ratios and on the mechanical efficiencies of the supercharger and the engine, but, between certain limiting values, a distinct increase in brake horsepower should result, even when taking into account the higher power required by the supercharger.

This subject has been treated theoretically by several authorities[3]. It was the desire of the authors hereof to make some laboratory experiments to confirm the theory and to give some quantitative values applying to a given set of actual conditions.

Tests were run in the aeronautical engine research laboratory at the Massachusetts Institute of Technology, Cambridge, Mass., during May and June, 1927. The general arrangement of the apparatus is shown in Fig. 1. The engine used was a Delco-light powerplant of 850 watts rated capacity, with a single cylinder of 2½-in. bore and 5-in. stroke. The load was applied by lamp banks and by fan blades added to the flywheel. A water-cooled cylinder and cylinder-head were especially designed for the engine and used throughout the tests, as it had been found that overheating difficulties were experienced with an air-cooled cylinder when supercharging to high pressures.

Before the tests, the set-up had been calibrated for the power absorbed by the fan at various engine-speeds and the generator losses under test conditions of current, speed and voltage had been determined in the electrical engineering laboratory. As the field was separately excited, no allowance for this was necessary. The cylinder-head of the engine was so designed that shims of varying thickness could be used with it, giving different expansion-ratios. The power absorbed by the lamp banks was measured by an ammeter and a voltmeter on the switchboard. The switchboard also had the necessary switches for applying the lamp banks and for exciting the field; a two-pole double-throw switch for connecting the armature either to the load or to the

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[2] Junior mechanical engineer, aeronautical engineering laboratory, Naval Aircraft Factory, Philadelphia; formerly instructor in aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

[3] See Automobile and Aircraft Engines, by Arthur W. Judge, 1921 edition, p. 397.

power mains for starting the engine, the generator being used as a motor for this purpose; and a tachometer and counter for measuring the engine-speed. A rheostat was used to vary the field current.

An eccentric-type rotary blower, driven by a separate electric motor, was used to supply the supercharging pressure, which was controlled by a bypass around the blower. Three tanks were provided to damp out the air pulsations caused by the engine and blower, so that air entering the first of the chambers could be measured by a rounded ½-in. orifice placed in the end of the tank. The pressure drop through the orifice was measured by an alcohol micromanometer. Elaborate arrangements were made to maintain the entire system free from leakage, and, a number of times during the investigation, it was tested and found practically air-tight.

To make the experiments of as broad an application as possible, it was decided to obtain data over a wide range of compression and expansion ratios, and therefore it was necessary to suppress detonation by using a non-detonating fuel. The fuel used was Colonial ethyl-gasoline of 0.735 specific gravity. Its heating value was taken as 19,000 B.t.u. per lb. The fuel rate was measured by taking the time for 20 cc. to flow from a burette. Air density was measured by a calibrated aneroid barometer and wet and dry-bulb thermometers placed in the draft from the flywheel and fan. The temperature of the air entering the orifice and the temperature of the air delivered to the carbureter were measured by thermocouples connected to a Leeds & Northrup potentiometer. The air, after leaving the blower, was passed through a cooler to maintain as nearly as possible the same carbureter-inlet temperature for all tests.

Tests were made at five different expansion-ratios, as found by measuring the clearance with oil and by computation. They are designated by number in the report, as follows: No. 1, 4.17 to 1; No. 2, 4.83 to 1; No. 3, 5.21 to 1; No. 4, 5.64 to 1; and No. 5, 6.32 to 1. All tests were made with the same setting of the carbureter, throttle and spark advance, as it was found that little or no gain in engine performance could be obtained by varying the carbureter setting and spark advance for each set of test conditions.

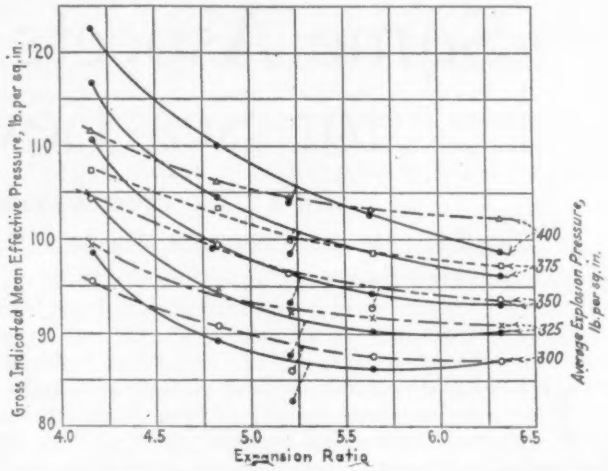


FIG. 2—GROSS INDICATED MEAN EFFECTIVE PRESSURE

Solid Lines Are Used to Show the Pressures Determined by the Tests, and Broken Lines to Show the Pressures Obtained from Calculations, Assuming the Same Conditions of Charging Pressure and Expansion Ratio

The speed was held as near to 1300 r.p.m. as possible for all tests. The temperature of the discharged cooling-water was fairly constant, varying from about 180 to 200 deg. fahr. Previous tests had shown that there was little if any change in engine performance through this temperature range. The variable, besides the ex-

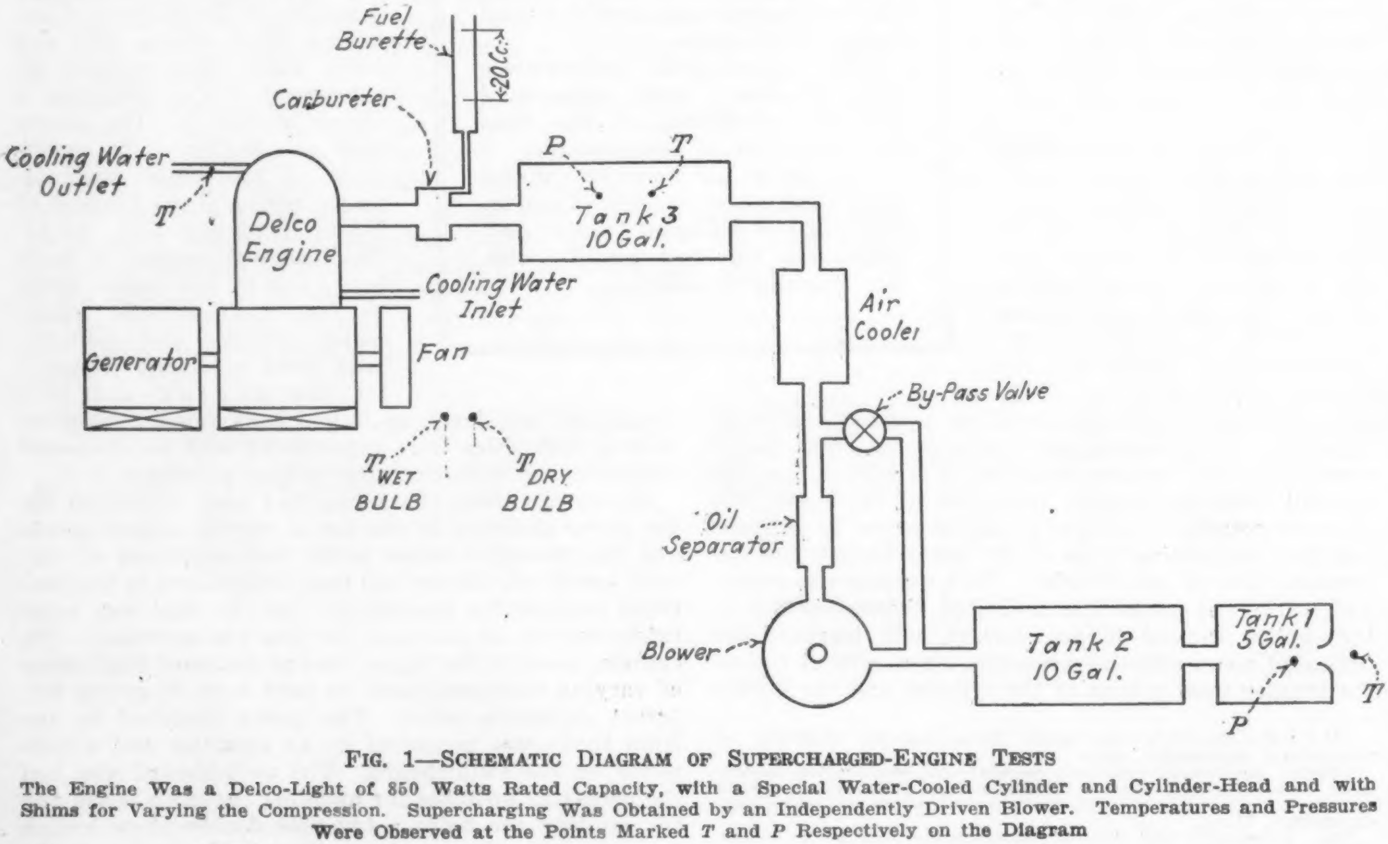


FIG. 1—SCHEMATIC DIAGRAM OF SUPERCHARGED-ENGINE TESTS

The Engine Was a Delco-Light of 850 Watts Rated Capacity, with a Special Water-Cooled Cylinder and Cylinder-Head and with Shims for Varying the Compression. Supercharging Was Obtained by an Independently Driven Blower. Temperatures and Pressures Were Observed at the Points Marked T and P Respectively on the Diagram

pansion ratio, was the supercharging pressure, which was measured at the carbureter air-inlet. The following readings were taken at pressures ranging from atmospheric to 9 in. of mercury: speed in revolutions per minute; armature voltage and current; supercharger pressure in inches of mercury; pressure at the air orifice in inches of alcohol; the minimum and maximum explosion-pressures in the cylinder, measured with a Bureau of Standards indicator; temperatures in degrees fahrenheit of the air at the orifice, the inlet air at the carbureter, the cooling water leaving the cylinder, and the wet and dry-bulb temperatures of the psychrometer; the time required in seconds for 20 cc. of fuel to flow; the barometer; the spark advance; and the carbureter setting.

The combustion chamber was cleaned and the valves ground each time the expansion ratio was changed, assuring the starting of each test with the same mechanical condition of the engine. The air system was also tested for leaks with each expansion ratio. Two

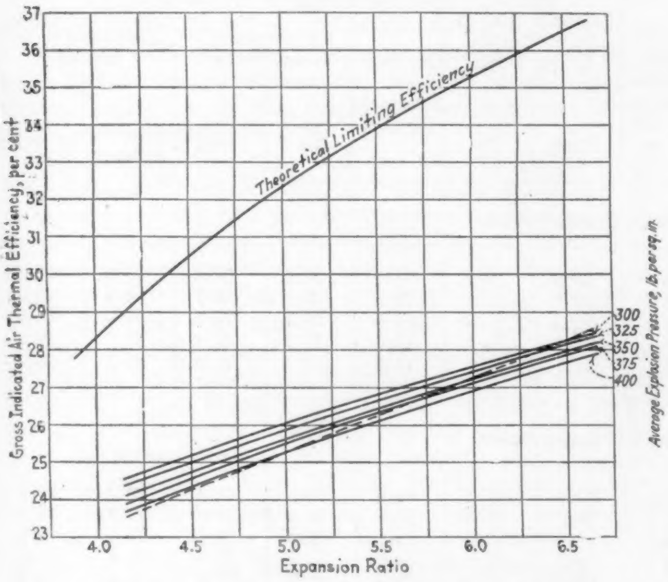


FIG. 3—GROSS THERMAL-EFFICIENCY CURVES

The Lower Group of Solid Lines Shows the Observed Gross Indicated Thermal Efficiency in Per Cent, Based on the Weight of Air Consumed, at Average Explosion-Pressures of 300, 325, 350, 375, and 400 Lb. Per Sq. In., for a Supercharged Engine at 1300 r.p.m. The Dash Line Shows the Calculated Efficiency at the Various Expansion-Ratios. The Upper Curve Is from H. R. Ricardo's Figures for Theoretical Limiting Efficiency with a 20-Per Cent-Rich Mixture in a Normal Engine

check-runs were made, one on ratio No. 2 and one on ratio No. 3. The results for these runs checked within the limits of experimental accuracy. On finishing the last test, a determination of the friction horsepower of the engine was made by motoring at running temperatures at 1300 r.p.m. with test voltage. As all the tests were made at the same speed, only one determination of the friction horsepower was needed. This was found to be 0.73 hp., equivalent to a mean effective pressure of 18.1 lb. per sq. in.

CALCULATIONS AND CORRECTIONS

All the observed brake horsepowers were corrected for a temperature of 60 deg. fahr. and a barometer of 29.92 in. The resulting values are designated as the corrected brake horsepower and are used in the compu-

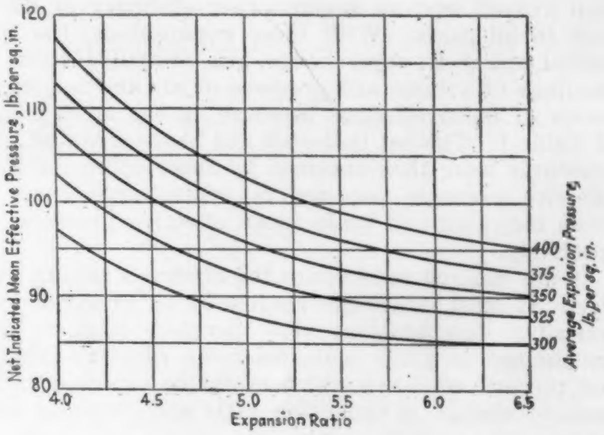


FIG. 4—NET INDICATED MEAN EFFECTIVE PRESSURE

Each of These Five Curves Shows the Net Indicated Mean Effective Pressure of the Supercharged Engine at 1300 R.P.M. in Lb. per Sq. In. with a Certain Average Explosion-Pressure and a Range of Expansion Ratios

tation of the brake mean effective pressure. The Bureau of Standards formula used for correcting the brake horsepower is

$$\text{B.hp. (corrected)} = \text{B.hp. (observed)} \times \frac{29.92}{B}\sqrt{\frac{T}{520}}$$

where

B is the observed barometer-reading in inches of mercury

T is the absolute temperature of the air entering the carbureter in degrees fahrenheit

The fuel rate in pounds of gasoline per brake horsepower per hour is computed from the observed brake horsepower because the fuel rate depends on the actual power developed at the time of the test.

It was found, early in the experiments, to be very difficult to hold the mixture ratio constant or to run with comparatively lean mixtures, on account of irregularities in carburetion. This necessitated using a somewhat over-rich mixture for all tests. To eliminate the mixture-ratio variable from the tests, thermal efficiencies have been calculated on the basis of the air consumed by the engine, using the heating value of air when burned with gasoline as given by H. R. Ricardo[4], 1290 B.t.u. per lb. of air.

As the power input to the supercharger depends on the particular design used, no measurements of this quantity were made, but the power required to supercharge was allowed for by assuming adiabatic compres-

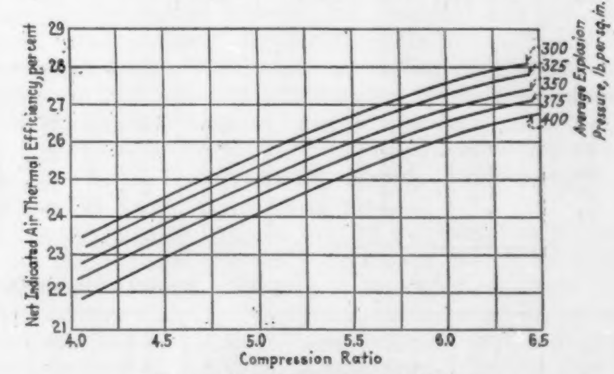


FIG. 5—NET-EFFICIENCY CURVES

The Lines on This Chart Are Equivalent to the Lower Solid Lines in Fig. 3, Except that They Are Changed from Gross Indicated Efficiency to Net Indicated Efficiency

[4] See Engines of High Output, by Harry R. Ricardo, p. 15.

sion and an over-all supercharger efficiency of 60 per cent in all cases. With these assumptions, the theoretical power to supercharge was computed from the readings of volume and pressure of air and is given in terms of mean effective pressure in the sixth column of Table 1. The net indicated and brake mean effective pressures were then obtained by subtracting the mean effective pressure required to supercharge from the gross indicated and brake mean effective pressures respectively.

It was desired to compare the observed results, relatively at least, with the results to be expected theoretically. Computations were therefore made to show the changes in gross indicated mean effective pressure and thermal efficiency which might be expected on the basis of change in expansion ratio and charging pressure.

Run No. 5 was chosen as a basis of comparison, since this was the run during which the charging pressure was nearest to atmospheric. Table 1 shows that the charging pressure during this run was 0.2 in. of mercury below atmospheric and the gross indicated mean pressure was 87.1 lb. per sq. in. The gross indicated thermal efficiency, as shown on Fig. 3, was 28 per cent.

Theoretical Results Computed

Computations for the expected gross indicated mean effective pressure were made on the assumption that the indicated mean effective pressure would vary directly as (*a*) the total volume of the cylinder; (*b*) the absolute charging pressure, since the charging temperatures were held practically constant; and (*c*) the expected gross indicated thermal efficiency. Assumption (*a*) is not strictly correct, as it does not account for the

TABLE 1—RESULTS OF TESTS

Run No.	Ratio No.	Expansion Ratio	Pressure at Carbureter Inlet, In. of Mercury	Brake Mean Effective Pressure, Lb. per Sq. In.			Friction Mean Effective Pressure, Lb. per Sq. In.	Indicated Mean Effective Pressure, Lb. per Sq. In.		Mechanical Efficiency, Per Cent	Air Thermal-Efficiency, Per Cent		Calculated Gross Indicated	
				Gross	For Supercharging	Net		Gross	Net		Brake Net	Indicated Gross	Mean Effective Pressure	Thermal Efficiency
300 Lbs. per Sq. In. Maximum Explosion Pressure														
1	1	4.17	5.5	80.5	3.4	77.1	18.1	98.6	95.2	81.6	19.3	24.6	95.5	23.3
2	2	4.83	2.5	71.0	1.4	69.6	18.1	89.1	87.7	79.6	20.1	25.7	90.9	25.2
3	3	5.21	1.4	64.5	0.8	63.7	18.1	82.6	81.8	78.0	20.4	26.4	88.0	25.8
4	4	5.64	0.6	68.0	0.3	67.7	18.1	86.1	85.8	79.0	21.2	27.0	87.7	26.9
5	5	6.32	—0.2	69.0	...	69.0	18.1	87.1	87.1	79.2	22.2	28.0	87.1	28.0
325 Lb. per Sq. In. Maximum Explosion Pressure														
6	1	4.17	7.1	86.5	4.5	82.0	18.1	104.6	100.1	82.8	19.2	24.4	99.7	23.3
7	2	4.83	4.0	76.0	2.4	73.6	18.1	94.1	91.7	80.8	20.2	25.9	94.8	25.2
8	3	5.21	2.9	69.5	1.6	67.9	18.1	87.6	86.0	79.2	20.4	26.4	92.2	25.8
9	4	5.64	2.0	72.0	1.1	70.9	18.1	90.1	89.0	79.9	21.0	26.8	91.8	26.9
10	5	6.32	1.0	72.0	0.6	71.4	18.1	90.1	89.5	79.9	22.0	27.9	90.8	28.0
350 Lb. per Sq. In. Maximum Explosion Pressure														
11	1	4.17	8.8	92.5	5.8	86.7	18.1	110.6	104.8	83.7	19.0	24.1	104.5	23.3
12	2	4.83	5.6	81.5	3.5	78.0	18.1	99.6	96.1	81.8	20.2	25.8	99.5	25.2
13	3	5.21	4.3	75.0	2.6	72.4	18.1	93.1	90.5	80.5	20.4	26.2	96.3	25.8
14	4	5.64	3.4	76.0	2.0	74.0	18.1	94.1	92.1	80.7	20.9	26.6	92.8	26.9
15	5	6.32	2.4	75.0	1.4	73.6	18.1	93.1	91.7	80.5	21.9	27.7	93.5	28.0
375 Lb. per Sq. In. Maximum Explosion Pressure														
16	1	4.17	10.3	95.8	7.0	88.8	18.1	116.6	109.6	84.5	18.7	23.9	107.5	23.3
17	2	4.83	7.0	86.5	4.5	82.0	18.1	104.6	100.1	82.8	20.2	25.7	103.5	25.2
18	3	5.21	5.7	80.5	3.5	77.0	18.1	98.6	95.1	81.6	20.3	26.0	100.0	25.8
19	4	5.64	4.7	80.5	2.8	77.7	18.1	98.6	95.8	81.6	20.8	26.4	98.7	26.9
20	5	6.32	3.7	78.0	2.2	75.8	18.1	96.1	93.9	81.1	21.8	27.6	97.3	28.0
400 Lb. per Sq. In. Maximum Explosion Pressure														
21	1	4.17	12.0	104.5	9.0	95.5	18.1	122.6	113.6	85.5	18.3	23.6	111.8	23.3
22	2	4.83	8.5	92.0	5.6	86.4	18.1	110.1	104.5	83.5	19.7	25.2	106.3	25.2
23	3	5.21	7.2	86.0	4.6	81.4	18.1	104.1	99.5	82.5	20.1	25.7	104.3	25.8
24	4	5.64	6.1	84.5	3.8	80.7	18.1	102.6	98.8	82.4	20.6	26.2	103.5	26.9
25	5	6.32	5.0	80.5	3.0	77.5	18.1	98.6	95.6	81.6	21.6	27.4	102.3	28.0

change in volume of residual gases in the cylinder due to the change in volume of the combustion space. It was believed, however, to be as accurate as the test results warranted.

The expected gross indicated thermal efficiency was computed on the assumption that it would be purely a function of the expansion ratio and would vary in the same ratio as the air-cycle efficiency.

From the results of the tests and calculations, the curves accompanying this report were constructed. The points of observed mean effective pressure were found to lie on smooth curves with the exception of the runs made at the 5.21-to-1 expansion-ratio, which all fell considerably below the curves for the other runs. Since this was probably due to experimental error, the points taken from the 5.21-to-1-ratio runs were disregarded in drawing the curves. The efficiency results fell on smooth curves, within the probable error of the tests, in all cases.

Fig. 2 shows the observed and computed gross indicated mean effective pressure plotted against the expansion ratio for five different average explosion-pressures. The observed indicated mean effective pressure was found by adding the friction mean effective pressure of 18.1 lb. per sq. in. to the observed brake mean effective pressure.

Fig. 3 shows the observed and the computed gross indicated air thermal efficiency plotted against the expansion ratio for the different average explosion-pressures. The observed indicated air thermal efficiencies were obtained by dividing the brake air thermal efficiencies by the mechanical efficiency of the engine at that load. On this curve sheet also is plotted H. R. Ricardo's values[5] for the theoretical limiting thermal efficiencies of a normal engine with a 20-per cent-rich mixture. Figs. 4 and 5 are similar to Figs. 2 and 3 except that they are based on the net observed values of the indicated mean effective pressure and indicated thermal efficiency. Fig. 6 shows the pressure required to supercharge engines with the different expansion-ratios to the same average explosion-pressure, curves being drawn for five different explosion-pressures.

Results and Conclusions

The results of primary interest are shown by the curves on Figs. 2, 3, 4 and 5, and in Table 1. Figs. 2 and 4 show that, for any given average explosion-pressure, the larger values of both the gross and the net indicated mean effective pressure are found with the lower expansion-ratios, and as the expansion ratio is increased the indicated mean effective pressure falls off rapidly at first and then decreases more slowly. It will be noted in Fig. 2 that, at the lower expansion-ratios, the observed mean pressures are considerably higher than the calculated mean pressures, even though the assumption that charge weight is proportional to total cylinder-volume would lead one to expect that the computed curves would give rather high mean pressures for the low ratios. The difference is especially marked with the higher supercharging pressures. This discrepancy has not been definitely accounted for. One possible explanation is that the large overlap of the valve timing in this particular engine allowed the residual gases to be partially blown out by the incoming charge. This effect probably would be greater with the higher supercharging pressures used for the high explosion-pressures at the low expansion-ratios.

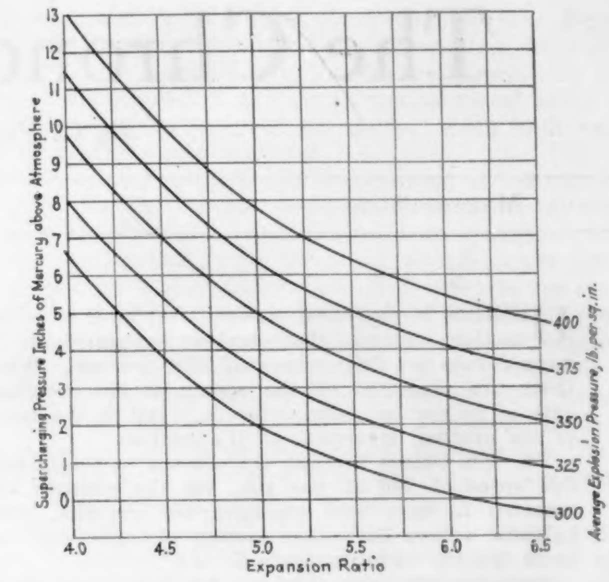


FIG. 6—SUPERCHARGING-PRESSURE CURVES

These Curves Show the Supercharger Pressures Required for the Several Average Explosion-Pressures Used in the Tests with Varying Expansion-Ratios

In general, it is evident that the indicated power obtained at the lower expansion-ratios is greater than at the higher ratios when supercharged to the same average explosion-pressure. This is in agreement with the theoretical treatment of the subject by A. W. Judge, who gives a table[6] of calculated values for a normal engine with an expansion ratio of 5 to 1 and for a supercharged engine with an expansion ratio of 3.5 to 1. The explosion pressures and temperatures are very nearly the same. In the case of the high-compression engine no supercharging was assumed and the indicated mean effective pressure is given as 144 lb. per sq. in. The low-compression results are based on supercharging to secure the same explosion-pressure as in the high-compression engine and the gross indicated mean effective pressure is found to be 188 lb. per sq. in.

Figs. 3 and 5 show that the gross and net indicated thermal efficiencies increase with increase in expansion ratio at constant explosion-pressure. This is to be expected, since it is the expansion ratio rather than the compression ratio that controls the cyclic efficiency. Here the agreement between the observed and the computed values is close. Referring again to the theoretical treatment by A. W. Judge, an indicated thermal efficiency of 31.5 per cent is given for the 5-to-1-compression engine, and a gross indicated thermal efficiency of 25.5 per cent is computed on purely theoretical grounds for the 3.5-to-1-compression engine, supercharged to secure the same explosion-pressure.

The curves also indicate that at a constant expansion-ratio the thermal efficiency decreases as the explosion pressure is raised. This is to be expected, since it is well known that the losses due to increase of specific heat and the direct heat-losses increase as the average temperature of the cycle is increased. In the case of these tests, the increased compression-pressure increases the pressures, and hence the temperatures, throughout the cycle.

[5] See Engines of High Output, by Harry R. Ricardo, p. 48.

[6] See Automobile and Aircraft Engines, by Arthur W. Judge, 1921 edition, p. 430.

The Chronoteine Camera

By C. FRANCIS JENKINS[1]

ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS

HEREIN is described a time-stretching or slow-motion camera that makes exposures at a normal rate for this camera of 3200 per sec. When these are projected on the screen at the standard rate of 16 per sec., the action is 1/200 of the speed of the original movement of the subject.

The film passes through the camera at the incredible speed of 200 ft. per sec., yet the pictures are asserted to have real photographic qualities, with halftone values like other motion pictures, and not to be "jumpy" when projected.

These results are obtained by unique construction whereby the film is moved continuously by an electric motor while the exposures are made through a series of 48 matched lenses mounted in a rotary disc that passes them before a fixed shutter.

Despite the speed of operation, the duration of exposure of each picture or frame is more than 25 times that possible with an intermittent-film camera.

This new camera affords a means for the study of many problems in science and engineering, some of which are not possible of accurate solution in any other way. Various applications of the instrument are suggested by the author.

THIS is a different camera, a time-stretching camera.

In the usual motion-picture camera, the film is pulled into position for each individual exposure by a pair of hooks engaging perforations in its margin, and then the shutter opens and closes to make the exposure. This is repeated over and over, 16 times per sec., until the action is recorded. As there are 16 exposures or frames per foot of film, obviously 1 ft. of film passes the exposure aperture in the camera every second.

By making the hook mechanism of very little weight, about 10 ft. of film per sec. can be passed through the camera; that is, about 160 exposures per sec., or 10 times standard speed. When these are projected on a screen at standard speed, 16 frames per sec., grotesque effects result. But for study purposes by the scientist or the engineer, a 10-to-1 reduction in the speed of an object is inadequate; a reduction of 200 to 1 in speed of the object photographed seems to be the lower limit for useful application of such a method of analytical study. This would require, however, that the hooks engage the film, move it into position with microscopic accuracy, and release it 200,000 times per min. Such intermittent movement is obviously impossible; continuous movement of the film is the only solution.

It may be that I had some very elementary idea of the requirements when, nearly 35 years ago, I conceived a camera in which the lenses and film should move continuously and the shutter should stand still. This is the way the chronoteine camera is built.

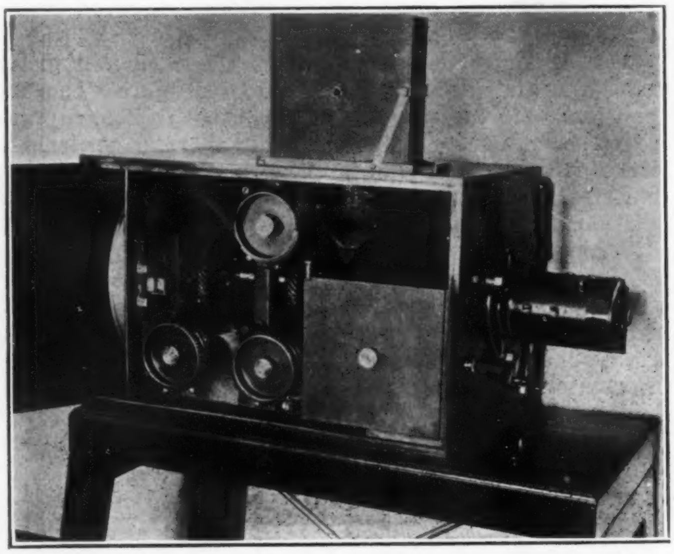


FIG. 1—THE CHRONOTEINE CAMERA FOR THE STUDY OF HIGH-SPEED SUBJECTS

This Unique Camera Makes Pictures at the Rate of 1600 to 4000 per Sec., and When These Are Projected at the Standard Rate of 16 Exposures per Sec., the Motion of the Subject Photographed Is Slowed Down 200 Times. The Film Moves Continuously While Exposures Are Being Made Through a Series of 48 Matched Lenses Set in a Disc That Is Rotated by an Electric Motor

MAKES 3200 EXPOSURES PER SEC.

The normal rate of exposures for this camera is 3200 pictures per sec. on standard motion-picture film. Projection of these pictures at the normal rate of 16 per sec. makes the rate of action 1/200 of the speed of the original movement and 1/20 the rate of the slowest slow-motion films frequently shown in picture theaters. It photographs successfully objects which the intermittent-film camera cannot photograph at all for purposes of study.

It is admitted that this speed seems incredible, for it means that, at the rate of 3200 per sec., 200 ft. of film passes through the camera in 1 sec. Yet that is exactly what happens. And at that speed 16 pictures or frames are put on every foot of the film with such exactness that, when magnified by projection on a motion-picture screen, the pictures are not jumpy. The camera, shown in Fig. 1, is so unusual as to justify a brief detail description, for it is a new tool available to the engineer, an aid to further progress in the industries.

The mechanical problem of moving the film and the optical problem of sufficient exposure were solved readily enough, but I worked for 25 years before I learned how to retain the film successfully in the exact focus of the lens during exposure without the film catching fire from the friction. In time I found that film moving 200 ft. per sec. attracts air to its surface and holds it

[1] Jenkins Laboratories, City of Washington.

with great tenacity, so I solved this problem by building a narrow fixed channel through which the film passes in the focus of the lenses, guided exactly in the middle of the channel by the films of air clinging to either face of the motion-picture film.

Rotating Disc Carries 48 Matched Lenses

For the lens image to follow constantly moving film, the lenses were made to move in synchronism with the film. A plurality of lenses are carried in a rotating lens-disc. Various disc sizes were tried more or less successfully until a lens disc about 13 in. in diameter and containing 48 matched lenses finally was adopted. The lenses are set in lens pockets in the periphery of the disc, accurately spaced, and all at exactly the same radial distance, as seen in Fig. 2. This lens disc must be of light weight so that it will have a quick pick-up and yet be strong enough for safe use at high rotative speeds. An alloy finally was found which acceptably met all requirements. This alloy disc weighs but 60 per cent as much as a disc of aluminum, although it machines like soft gray cast-iron and "stays put" when finished, needing no aging or seasoning before or after making. A steel band is shrunk on the disc when it is to be used for extremely high speed.

The spacing of the lens pockets was far more difficult to attain practically than was at first anticipated, but finally was attained by the use of a dividing-head of our own make.

The finished lens-disc is mounted to rotate inside the camera casing, so that the lenses cross closely adjacent to a fixed-shutter opening in the front wall of the casing.

By far the most difficult of all the problems encountered was that of matching the lenses, which any photographer who has tried to match even two lenses will recognize. The lenses first employed were Bosch & Lomb Zeiss Tessar F-3.5 lenses of 2-in. focus. They were bought for matched lenses but were only "commercially matched," as was explained to us later. As nothing short of scientifically matched lenses was permissible in our work, we set about matching these lenses, and after months of tedious effort the lenses are now so accurately matched that in the test room each of them, coming in succession into position, projects a spot of light on exactly the same place on a target 40 ft. away. The aperture in the gold-leaf mask in the focus of the lens that projects this spot is so small that it cannot be seen when held between the eye and a strong light.

After getting the lenses into exact successive register, the next problem was to fasten them against displacement, for clamping a lens transversely of the optical axis immediately threw it out of position and the subsequently projected pictures were jumpy on the screen. This problem was solved eventually by clamping the lens axially, and steadiness of projected pictures was retained.

Exposures Longer Than with Intermittent Camera

In the camera the lens disc is mounted on one end of a steel shaft, upon the other end of which, outside of the box, a 4-hp. series-wound 6-volt motor is mounted to rotate it. Being a series-wound motor, the speed increases as the applied voltage increases. We usually use 12 volts on the motor, which gives approximately 3200 exposures per sec., and we call this normal speed for this camera. Six volts gives about 1600 exposures per sec., and 18 volts gives about 4800 per sec. Beyond 18 volts, commutator sparking is very bad, so a little jockeying is resorted to to get doubled speeds, say 8000 to 10,000 exposures per sec., a maximum of about 500 times reduction in speed for study. Such high reduction rate is rarely required.

One of the mysteries of this camera is the exposure time. To the intermittent-camera operator it seems inconceivable that we can get exposure enough at these high speeds, using only the superspeed negative film of commerce. The explanation is that, whereas for sharpness on the same moving object an intermittently moved film can have at most not more than 5-per cent exposure, with rotary lenses and constantly moving film we get easily more than 150-per cent exposure, more than 25 times the exposure possible with an intermittent-film camera. This sounds like another paradox but the explanation is in the fact that adjacent lenses overlap in time in their successive exposures.

While this camera is very simple, and almost anyone can learn to use it successfully, best results come after a certain technique has been acquired. To illustrate, in photographing the flight of a big-gun shell, the camera is started first, then the firing contact of the gun is pressed; whereas, in photographing athletic turns, the athlete is started first, then the switch on the camera motor is closed. If the camera were started first, the athlete might not get away before the film ran out. However, in either event, the camera man cannot change his mind effectively after he presses the trigger.

Several Ways of Timing Exposure Rate

A record of the exposure rate, when required, may be obtained in several ways:

(1) A 20-in. dial clock can be set up in the picture to be photographed with the subject. As the hand sweeps over the dial at a rate of 60 revolutions per sec., the time divisions are fairly easily read in the photograph

(2) In another method a tuning-fork of 500 beats per sec. reflects light from a tiny mirror mounted on the fork. The light flashes are photographed on the film as time-spaced dots

(3) A high-speed gas lamp may be photographed on the film at any speed desired, 100,000 per sec. if required. This method records very fine time-divisions

(4) The scheme we most frequently employ is simply to count the revolutions of the lens-disc motor-shaft with any good revolution counter and multiply by 48, the number of lenses passing the aperture at each revolution. With 12 volts on the 6-volt 4-hp. motor, a speed of 4000 r.p.m. is attained in about ½ sec. and is then held for the 1¾ sec. necessary to get the film through the camera at the rate of 400 ft. in 2 sec. and record 6400 exposures, or exactly 3200 exposures per sec.

It may be of passing interest as evidence of the high speed of this camera to note that when, instead of rewinding it, 200 ft. of film is shot up into the air by the camera, the film rises straight and stiff into the air for about 5 ft., then promptly breaks up into equal lengths of approximately 14 in. each, the breaks so accurately spaced that most of the pieces exactly match in length.

The gears which drive the film sprockets are ½-in. face, cut-steel gears. All the bearings are bronze. The 6-volt motor is driven by one, two or three 6-volt storage-batteries, usually two automobile batteries. Consequently the camera is easily portable for field work

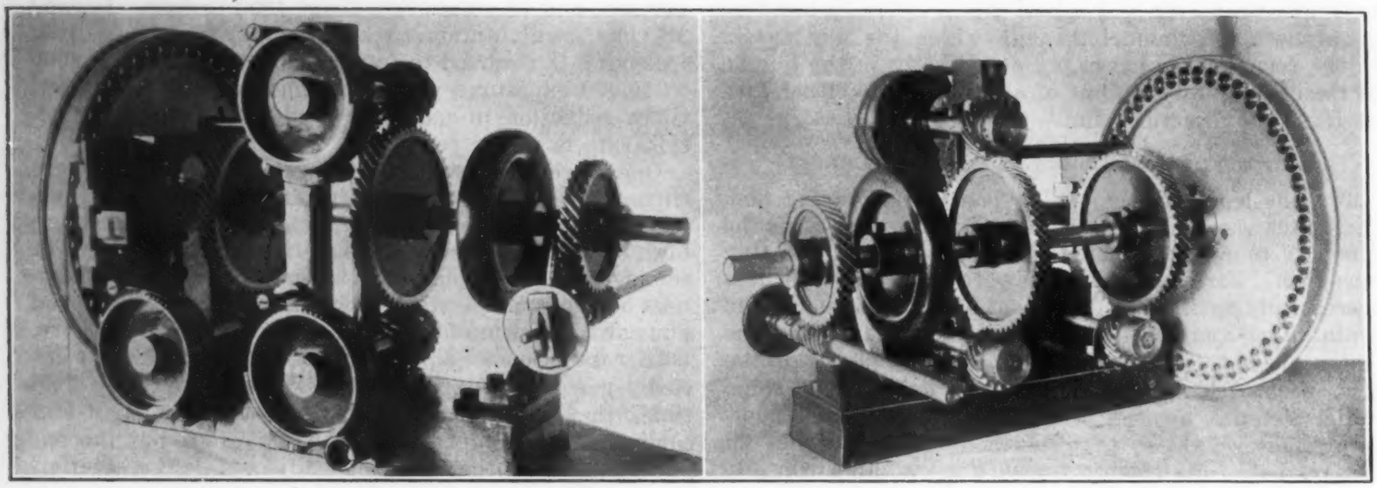


FIG. 2—LENS DISC, DRIVE GEARS AND RELATED MECHANISM OF THE SLOW-MOTION CAMERA

In the View at the Left Are Seen the Hooked Wheels That Drive the Film Strip at 200 Ft. per Sec. and the Vertical Air-Channel To Hold the Film in the Focus of the Lenses Without Its Touching Any Metal. At the Extreme Left and Right in the Two Views Can Be Seen the Lens Disc Mounted on the End of the Common Shaft That Carries the Gearing and Electric Motor. One of the Pinion Shafts Is Employed for Rewinding the Film after the Exposures Have Been Made

beyond the reach of house current and for mobile use. It weighs complete only about 75 lb. and is readily separated into smaller, lighter pieces, easily handled for moving it from place to place.

The camera is threaded in daylight, like any hand camera, from film boxes previously loaded in a darkroom or at night. Eastman standard stock superspeed negative film is used. Prints from the negatives can be made in any film laboratory and projected in any standard projection machine.

The camera can be focused for short distances, but without adjustment any object beyond 20 ft. is in sharp focus. The field of vision has a width equal to half the distance from the camera to the object.

The camera is fitted with its own detachable support of approximately fixed elevation but can be adjustably inclined.

Sunshine is adequate for illumination. If artificial light is employed, it should be equal to direct sunshine.

PICTURES HAVE GOOD PHOTOGRAPHIC QUALITIES

Attention is called to the good photographic quality in the pictures, which is unusual in such high-speed studies. The pictures are true photographic pictures having half-tone values like other motion pictures, not mere shadowy outlines of grayish silhouettes. They are made out-of-doors as well as in the laboratory, of large subjects or small subjects, and from a moving vehicle as readily as from a fixed platform.

Aside from the economy of this quick method of motion study, a record is kept which can be examined again and again and by which, as has already happened, new and unsuspected phenomena may be discovered.

The visual presentation of any subject study is the natural and most effective method, especially if the results are to be shown to the financial executive to secure the release of funds for other than customary purposes. To this end, slow motion-picture studies are ideal.

The chronoteine camera is an instrument for the study of many problems in science and engineering, some of which are not possible of accurate determination in any other way. Some additional applications of this instrument which immediately suggest themselves are a study of gun recoil, shell trajectories and plate impacts, airplane propeller and landing-gear action, bursting of balloons and air hose, tire action over obstructions, water streams, propagation of flame, engine-valve rebound at high speed, cam-roller jumping, crankshaft whip; transformer explosions and circuit-breaker arcs; shuttle thread knots and bobbin action, brake-shoe and draft-gear application; in fact, anything that moves too fast for the eye to follow can be shown slowed down to 1/200 speed or more and can be examined in detail at leisure and repeatedly.

Third Differential-Gear on Six-Wheel Vehicle

AT the joint meeting of the Institution of Automobile Engineers and the Institute of Transport held recently in London, G. W. Watson, member of the Council of the I.A.E., said that theoretically a third differential-gear appears to be necessary on six-wheel vehicles, but that in some tests he had made by drawbar dynamometer he had become convinced that this is not actually the case. He hauled a loaded six-wheel vehicle of the rigid-frame type; a heavy-duty machine with pneumatic tires inflated to 110 lb. per sq. in. The drawbar resistance of the vehicle had been taken with the tires at that inflation pressure. Then, by decrements of 10 lb. pressure at a step, the left front driving-wheel was reduced in pressure, and further tests were made over the same route. Then the right front wheel tire pressures were reduced until the tires of the front axle of the bogie had only 20 lb. per sq. in. inflation pressure, as against 110 lb. for those at the rear. Under these extreme conditions, the increase of drawbar resistance was less than 8 per cent. He concluded from this that there is no justification for the contention that a third differential-gear should be installed; in fact, that the introduction of such additional gear would eliminate the advantages now secured with the rigid-frame six-wheel vehicle.

Tomorrow's Motorcoach Legislation

Discussion of A. M. Hill's Transportation Meeting Paper[1]

INTERSTATE regulation of motorcoach operation was very simple prior to March 3, 1925, on which date the United States Supreme Court handed down decisions that altered suddenly and completely the conditions of motorcoach operation across State borders. Theretofore, nearly all States having regulatory laws assumed the power to regulate lines crossing their borders in the same way that they regulated lines operating wholly within the State, and interstate operators obtained certificates of convenience and necessity.

As a result of the decisions of the Supreme Court in the Buck and Bush cases, the regulatory conditions, particularly in the populous parts of the East and the Middle West, became almost chaotic, as there is now no restriction on the number of lines that may operate in interstate traffic.

So many complaints were received from railroads and other established transportation companies that the Interstate Commerce Commission held a series of hearings throughout the country to ascertain the effect upon the railroads of this new competition, with a view to submitting a report and recommendations to the present Congress regarding needed legislation.

A committee of motorcoach operators has been working for 2 years upon a bill to present to Congress, and the motorbus division of the American Automobile Association has taken over this work, has cooperated in it with the National Association of Public Utility Commissioners and has conferred with representatives of the companies operating steam and electric railways.

Opposition of motor-truck interests prevented the passage in 1926 of a Federal bill that included regulations of interstate motor-truck lines as well as motorcoach lines. Passage of a revised bill to regulate passenger carriers only and to place this regulation in the hands of the various State commissions was also prevented.

It is hoped that the new bill introduced in the present Congress will have an excellent chance of passage and will be constructive in character and prove a boon to the development of motorcoach operation throughout the country.

In the discussion, it is admitted that long-haul motorcoach development would not have occurred except for the Buck and Bush decisions, but it is pointed out that uneconomic competition is an unhealthy condition and that, while regulation will not solve all the operators' troubles, one of the conditions sought to be guarded against in the new legislation is the operating of more than one company between the same terminals. Motorcoach operation for short distances is said to be decreasing, while long-haul operation is increasing, and motorcoaches are becoming more luxurious. One speaker holds that long-distance motorcoach travel is a passing phase because the railroads can handle this traffic cheaper. This idea is combated by another speaker, who cites instances of motorcoach operations over long distances with a speed and reliability closely approaching that of the railroads and carrying a much larger traffic. Fare differential is a controlling factor, according to one speaker, who tells of a check-up showing 30 round trips by motorcoaches in one day between New York City and Philadelphia, where train service is particularly good.

R. E. PLIMPTON[2]:—Is it good transportation economics to operate intrastate and interstate motorcoach business separately? As time goes on, is it not true that the highways will have to be given over to utilization by one company? It is very inefficient for separate companies to try to operate intrastate and interstate business over the same highways, particularly when they are limited as to space for carrying passengers.

What is the practical experience of the operators regarding the real value of regulation? I have had an impression that regulation is only the beginning of the battle. Many operators are inclined to feel that, if they can only get a law passed, all their troubles are solved and that the law is a panacea for every difficulty they ever had. The light in this room is good but I do not know of any law that would compel us to use it if we wanted to use a candle in its stead. No law could prevent us from using candles, but we use electric light because it is more convenient, easier to control and has many other advantages. I mention this because it seems that motorcoach and motor-truck operators would do well to consider the fact that they have to give real service to deserve the good-will of the public and to make the profit to which they are entitled, in addition to what legal protection they have, and I am in favor of giving them what is fair and due them.

CHESTER G. MOORE[3]:—Use of the highways by more than one company operating between the same terminals is the very condition that we wish to guard against if we can in this legislation. Undoubtedly, many motorcoach lines operated in the United States in interstate commerce are of public convenience and are necessary, but some are not. This condition should not exist and, with that thought in mind, we felt that the fairest method of preparing this bill for Congress was to allow the operators who had certificates before the case was handed down to receive a certificate automatically and make other operators prove convenience and necessity. Service to the public will not be as good if more than one line operates, in most instances; but, in some instances, service will be as good.

LONG-HAUL MOTORCOACH SERVICE INCREASING

An interesting development is taking place in the motorcoach industry that undoubtedly would not have occurred except for the Buck and Bush decisions; that

[1] The paper was printed in THE JOURNAL for December, 1927, p. 706. The author is president of the Blue and Gray Lines, Charleston, W. Va., and chairman of the board of directors, motorbus division, American Automobile Association. An abstract summarizing the paper and discussion briefly is printed herewith.

[2] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.

[3] Executive vice-president, United Motor Coach Co., Des Plaines, Ill.

is, in the long-haul motorcoach business. Lines now operate from Chicago to San Diego and to Los Angeles. Some of the operators are going into this business very extensively. I suppose that this activity never would have developed in so short a time had it not been that the door figuratively was thrown open, and anyone who wanted to operate in interstate commerce was allowed to start. It is an unhealthy condition to continue to ask the public to pay the same bill twice. For that reason I believe that, while regulation is not a solution of all our troubles, it is one of the most important things we have to take into consideration in the motorcoach business today.

The prevalent idea that motorcoach transportation is suited only for short distances is entirely wrong. In fact, motorcoach transportation for short distances is decreasing and the longer haul is increasing. This fact surprised me when I was compiling the statistics. I do not know why people ride from Chicago to the Pacific Coast in motorcoaches, but they do it. We operate a motorcoach line between Los Angeles and San Francisco and our fastest schedule is 14 hr. Many people ride in our motorcoaches in preference to riding in the fast luxurious trains on the railroads. That condition of healthy business in the motorcoach-operating industry in the West has been brought about by the progress made in improving equipment and by proper regulation in California. I think the same procedure will help interstate business.

Economics Favors Railroad Long Haul

Brigadier-Gen. Francis H. Pope[4]:—Not having any brief to hold either for the motorcoach or the railroad, I speak from the viewpoint of an outsider. People are taking long rides in motorcoaches for the same reason that they rode in the "jitney" automobiles, which are now obsolete. These long rides in motorcoaches will not continue for very long; it is just a passing phase. Certainly no one in this room would ride to the Pacific Coast in the newest observation motorcoach in preference to traveling on a luxurious limited railroad train.

A law which is higher than the Federal law is going to regulate this condition; it is the economic law. I do not believe, and I have seen no statistics yet to prove that I am wrong, that long-distance highway-operation will even approach long-distance railroad-operation. The chief appeal of the railroads is long-distance mass-transportation. We found that out in military circles and there is no reason why it should not hold true in commercial life. The automobile association would do much better if, instead of fighting the laws and fighting the railroads, it would get the railroads together and fight it out with them. The economic law is against you and it is bound to work that way.

As to proper regulation, you say the people who have the licenses now should be the ones who get them automatically later, that they should be allowed to use the highways but that no one who comes along later should get a license. But the railroad men can say the same thing. They can tell you that none of you ought to operate because they were on the ground first. There is a proper field for the railroads and a proper field for highway transportation. Those fields are separate and distinct.

F. C. Horner[5]:—I would like to tell General Pope of some information that I believe to be reliable on the motorcoach lines operating from Los Angeles to Denver. During 1926 these lines were running from two to five motorcoaches in the summer and one or two in the winter. They never had an empty seat. After a check-up made about 18 months ago at Denver, it was discovered that the motorcoaches in one day conveyed 134 passengers to Kansas City and St. Louis from Denver; that was for about an 8-hr. day on which all the railroads had only 22 passengers for the same points. Long-distance motorcoaches now operate regularly between Chicago and the West Coast and to some intermediate points such as St. Louis, Kansas City and Denver. There are several motorcoaches out of Chicago daily in the summer and they are usually well filled with passengers, at least to an extent that the operators think it is a paying proposition.

On the Pacific Coast, the Pickwick Stages run regularly from San Francisco to Portland, Ore., about 760 miles and over the mountains, in 31 hr. The average train time in the winter of 1926-1927 was 29 hr. A severe flood due to heavy rains in February and March tied up train service and motorcoach service, but I was informed that in certain instances the motorcoaches got through more quickly than did the railroad trains. A motorcoach would run up to where the roads were completely impassable and transfer the passengers across to another motorcoach on the other side of the obstruction or washout.

I would like to ask Mr. Moore a question regarding the motorcoach situation in West Virginia. Will there be an appeal to the Supreme Court of the United States on the decision that has recently been rendered there in connection with certain routes where motorcoach lines are competing with the railroads?

Interstate Motorcoaches Well Patronized

Mr. Moore:—I am not very familiar with the aspects of the case, but I understand that there will not and cannot be. I am under the impression that the decision is final.

Concerning whether long-distance transportation by motorcoach is just a passing fancy, the Pickwick Stages Co. has been in the business for 17 years and during all of that time the long-distance haul has been increasing steadily. We are now operating into St. Louis and will be operating into Chicago very soon. Instead of decreasing, the haul is increasing in length rapidly and we believe it is here to stay.

Mr. Horner:—Theoretically, it seems questionable that anyone would want to ride in a motorcoach between Chicago and San Francisco, but it seems to work out the other way in practice.

Brigadier-General Pope:—The people who ride that way are tourists. I will venture to say that nobody in this room going from San Francisco to Portland is going to sit in a motorcoach for 29 to 31 hr. One might go part way and stay all night at Shasta Springs and then go on to another point and stay over night; but, on through traffic, what is one to do with trunks and bags?

Mr. Horner:—In fact, those motorcoaches are carrying 25 passengers and anywhere from 1000 to 1800 lb. of baggage, express, newspapers and magazines, and almost anything in the way of high-class traffic that comes along. They are doing it as a regular thing.

Brigadier-General Pope:—That would require one to sit for 31 hr. with barely enough leg-room.

[4] S.M.S.A.E.—Chief of transportation service, Quartermaster Corps, United States Army, City of Washington.

[5] M.S.A.E.—Assistant to vice-president, General Motors Corporation, New York City.

MR. HORNER:—Adequate leg-room is provided for on those motorcoaches. They have a peculiar kick-up seat-arrangement which permits the passenger to sleep quite comfortably.

K. J. AMMERMAN[6]:—What the members in this room would do is no criterion as to what everybody in the United States will do. I venture the prediction that when this meeting is over every member who leaves and travels a distance requiring 2 or more hours will ride in a Pullman car, but thousands of people who leave Chicago at the same time will ride in day coaches. Price is the determining factor in the use of motorcoaches in many cases. There are motorcoaches running from Detroit to Cleveland, with a fare considerably less than the railroad fare. That largely accounts for traveling in the motorcoach, in exactly the same way that patronage of a day coach, as compared with a Pullman car, is secured.

If there is one place in the United States where train service is good, it is between New York City and Philadelphia. The distance is about 90 miles and a train is available almost any time, day or night, between the two cities. But a recent check made at Trenton, N. J., on motorcoaches going from New York City to Philadelphia, leaving out all local service, showed the number of round trips to be somewhere around 30. They carried more than 900 passengers that day between the two cities, and I do not believe all the people were tourists. I doubt very much if even a fair percentage of them were tourists. I think it was simply a matter of price, or of some other factor which is very hard to determine.

I do not agree with General Pope's opinion, that long-distance travel by motorcoach is a passing fancy, based on the fact that the chances are that very few of this audience would take a trip to the West Coast in a motorcoach except for the experience of taking it. The New York, New Haven & Hartford Railroad, through its subsidiary the New England Transportation Co., is running a motorcoach service from New York City to Boston, leaving at 9:00 a.m. and also at 9:00 p.m. That means one overnight run, and I do not think it is doing that for fun. It is doing it because there is a patronage for that run, a patronage which certainly is not derived from the public's desire to experience an overnight ride in a motorcoach.

[6] M.S.A.E.—Executive, American Car & Foundry Motors Co., New York City.

Motor Freight Transportation

THE freight revenue of the railroads is well toward $5,000,000,000 per year. No accurate estimate can be made of the cost of moving goods by other means, principally by water and on the highway by animal and motor power. We may reasonably assume that the 2,500,000 motor-trucks cost from $800 to $1,000 each, or at least $2,000,000,000. The cost may be considerably greater, but records are kept for too few to be at all definite. Water, animal and other hauling probably costs as much as the trucks, so that one can hardly doubt that a tenth of the income of the Country, estimated at around $90,000,000,000, goes to pay for freight transportation.

A large volume of freight transportation work is done without it being known whether it is done in the cheapest way. No set rules can be given; each case is individual, and must be studied individually. There have been many disappointing results from substituting trucks for older methods of hauling, due to selection of the wrong equipment, unwise operating methods, or the use of trucks for work they are not adapted to do. With information available, it is rather simple to calculate the cost of a transportation job with trucks and to compare it with the cost by other means. Data of reasonable accuracy are at hand, and the cost of the comparison is nominal in proportion to the possible saving if large-volume transportation is involved.

The first group of expense items in operating a motor-vehicle are those that continue day after day, when the vehicle is kept available for use; and are not affected by the amount of use. These items of fixed cost amount to about $10 per day for heavy-duty freight trucks. As soon as the truck begins to move, other expenses are incurred which continue as long as the truck runs, and are substantially proportional to the mileage. They are called mileage costs. These items approximate 15 to 25 cents per mile for trucks of 2 to 5 tons capacity, under ordinary circumstances. The depreciation is often considered a fixed cost at an annual fraction of the cost; but, as use rather than age destroys a truck, it is more logically treated as a mileage cost.

The ton-mile cost becomes less as the size of the truck is increased, as the daily mileage is increased and as the load carried is increased. When loaded too heavily, the wear and tear on the truck becomes so great that it overbalances the saving in other costs, and the total expense rises. Excessive speed is even worse than excessive load, especially on the tires. No specific load-value can be given beyond which further loading does not pay. It varies with several factors, of which road conditions and skill and care of the driver are most important. It is doubtful that a regular practice of loading more than 25 per cent above the rating is advisable.

The limit of daily travel of a draft horse is not over 20 miles in regular service, a haul of 10 miles out and return, to allow for stabling in the home barn.

Skilful truck operation, with the ideal condition of capacity load all the time, may bring the ton-mile cost to 6 or 7 cents, possibly under 6 cents. In practice it will usually be higher, but even the lowest possible cost is several times the rail cost for heavy bulk goods carried very far. Any one of several items of truck cost may approach, driver's wages alone often exceed, the total rail charge where the haul is more than a few hundred miles. In this Country nearly 2,500,000 trucks are in service with a load capacity of about 1.3 tons each. They could not do over 18,000 miles a year each even with skilful centralized operating control; so that the maximum possible performance is under 60,000,000,000 ton-miles a year. An average of half load and a mileage of 12,000 is as much as can be hoped for in practice and is more than is obtained, so that the real performance is not over 20,000,000,000 ton-miles per year, which is less than that of single railroads.

For a 1-day run, about 100 miles, truck transportation is faster than rail, often justifying its use for perishable goods or emergency shipments at advanced cost. For distances over a 1-day run, rail shipment is likely to be faster.

The larger the shipment, the longer the haul, or the less the handling time needed, the more likely it is that the goods should go by the larger-capacity agency, truck rather than horse, and rail rather than truck. Developments in the future may alter conditions. For example, ways are being found to lessen the cost of handling and crating small lots. One that has promise is a steel box of size to serve as a truck body.—Roy T. Wells in *Harvard Business Review*.

Data on Machinability and Wear of Cast Iron

By Thomas H. Wickenden[1]

Annual Meeting Paper *Illustrated with* Photographs and Chart

THE hardness or chemical composition of an iron is, by itself, no indication of the wearing property and machinability of the iron. Irons containing a large amount of free ferrite have been found to wear rapidly, whereas others having considerable pearlite or sorbite in their structure show good wearing properties. The presence in cylinder-blocks of excess-carbide spots or of phosphides of high phosphorus-content is deleterious, because such spots wear in relief and the material ultimately breaks out, acting as an abrasive that scores the surface of the piston and cylinder-walls.

Causes of wear in cylinder-blocks are discussed, and nickel, or nickel and chromium, intelligently added to the iron is suggested as a means of obtaining the correct microstructure for a combination of good wearing properties and machinability. Since greater hardness is the result of a harder matrix rather than of an increase in the number of carbide spots, it has been found to be a good index of the improved resistance to wear, and to overcome the difficulty due to the hammering of the valves into their seats.

Analyses of cylinder-blocks, pistons, clutch plates, brake drums, cams, and forming-dies, in which nickel and chromium have been used, are given, and the improvements secured in the performance of these parts are described.

CAST iron is an engineering material that possesses a multitude of commendable properties. It is low in cost, easy to cast and readily machined. These properties often have been the primary considerations in its selection for use in many parts. Its ability to resist certain types of wear has been recognized; but the characteristics of an iron excelling in its resistance to wear constitute a subject of much discussion among metallurgists and engineers, and their opinions are widely divergent. Any improvement in the wearing-property of cast iron is heartily welcomed by the engineering profession, but improvements in this property must not seriously interfere with its other primary properties; namely, low cost, ease of casting and ease of machining.

Although the problem of the improved wear of cast iron has not been entirely solved, some recent methods of increasing its durability will no doubt be of interest. Much discussion can be found in the literature regarding the relative wearing-properties of hard and soft irons. Numerous examples have been cited in which a soft iron has shown better wearing-properties than a hard iron under certain conditions. This fact may be regarded as a real news item, for the opposite is the usual occurrence and does not cause unusual comment. From this state of affairs the conclusion may be deduced that hardness alone is not necessarily a true index of the durability of cast iron but must be considered in conjunction with other characteristics, such as are revealed by the microstructure of the iron.

Variety and Character of Constituents

This is not strange when the various micro-constituents and their character are considered. These include graphite, having the softness of a soft lead-pencil; impure ferrite, having the characteristic of soft carbon-free iron; pearlite, having the characteristic of annealed spring-steel; sorbite, resembling heat-treated steel; spots of phosphide, a brittle material of considerable hardness in iron of high phosphorus-content; and spots of free carbide, a constituent of the hardest tool-steels. It is easy to conceive of many combinations of these constituents that would produce the same Brinell hardness. The hardness value of any iron, taken by the usual methods, is a composite result of the hardness and arrangement of these individual constituents.

Figs. 1, 2, 3 and 4 show the photomicrographs of several specimens of cast iron having almost the same Brinell-hardness, approximately 180. These show a wide difference in their microcharacteristics. Iron *A*, Fig. 1, is characterized by large graphite flakes, the matrix containing considerable pearlite, some free ferrite, and some free carbide. Iron *B*, Fig. 2, has small well-distributed graphite flakes, the matrix showing pearlite and spots of phospho-carbides and free ferrite. Iron *C*, Fig. 3, has small graphite flakes, the matrix showing pearlite, free cementite and some ferrite. Iron *D*, Fig. 4, contains medium-size graphite flakes, practically no free cementite, a small scattering of free ferrite, and combined carbon, which is largely in a sorbitic state.

In the photomicrograph of iron *A*, the dark area in the lower right corner shows the edge of an impression made by a Brinell-hardness ball under a 3000-kg. load. The dent shown at the left in iron *B* is an impression caused by a Shore hardness-test. The dark curved portion shown in iron *D* at the extreme left is the impression created by the 1/16-in.-diameter ball used for making tests with the Rockwell machine, using the *B* scale. Considering the areas covered by these various tests with relation to the size of the individual grains gives a good visual illustration of the statement that the hardness of cast iron is a composite result. From a study of these photomicrographs, it is easy to see that hardness alone is not a definite index of wearing-property.

[1] M.S.A.E.—Development and research department, International Nickel Co., New York City.

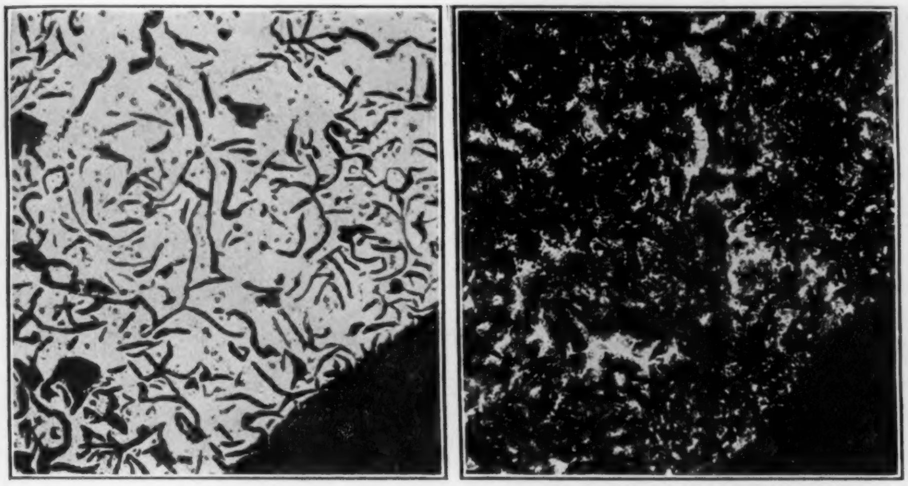


FIG. 1—MICROSTRUCTURE OF CAST IRON *A*

All the Irons Shown in Figs. 1, 2, 3 and 4 Are of 180 Brinell Hardness and Have the Same Magnification; Namely, 75 Diameters. In Each Figure, the Unetched Iron Is Shown at the Left, the Etched Iron at the Right. The Characteristics of Iron *A* Are Large Graphite Flakes and a Matrix Containing Pearlite, Some Free Ferrite, and Some Free Carbide. The Dark Spot in the Lower Right-Hand Corner of Each Sample Above Is the Impression of a Brinell-Hardness Ball under a 3000-Kg. Load

WEAR RESISTANCE OF DIFFERENT CONSTITUENTS

Since cast iron is a composite mixture, some conclusions can be drawn from the wearing characteristics of these various constituents. Graphite by itself is too soft to stand much pressure without crumbling, but, because of its nature, it is an excellent lubricant. It is porous and can absorb oil readily, thereby acting as an oiling-pad. A distinction must be made between flaked, or primary, graphite, which is a true graphite having lubricating properties, and temper carbon, which is in a different allotropic form and has more of the characteristics of lamp-black. The latter is the condition of the carbon in a malleable iron, the wearing characteristics of which are well known; that is, it resists wear when well lubricated but wears rapidly when scantily lubricated.

Ferrite, having characteristics similar to those of a very low-carbon steel, is not considered a good wearing-material. It has comparatively low tensile strength, abrades easily, and tends to gall on another rubbing surface, the result being a rough bearing surface that rapidly destroys itself.

In annealed steels having increasing quantities of carbon-content, the microstructure contains an increasingly large pearlitic area until, at about 0.80 per cent of carbon, the microstructure is fully pearlitic. It is the general consensus of opinion that, with increase of carbon, the wear-resisting properties of annealed steel are improved until the full pearlitic structure has been secured. Steels showing a sorbitic structure generally have greater hardness than have annealed steels of the same carbon-content and better wearing-property. A high-carbon pearlitic steel may, however, show better wearing-property than a low-carbon sorbitic steel. It is well known that the harder a gear steel is, the better it will wear. This holds true through the range of soft-steel and oil-hardened gears up to case-hardened gears, which have a high carbon-content on the surface that, when hardened, is in the form of martensite.

Remarkable resistance to wear is developed by a chilled white iron that contains large masses of iron carbide; but this material is, of course, practically unmachinable and is applicable only in special cases. Because the main constituent of this hard iron is free cementite, the conclusion must not be drawn that its presence is desirable in readily machinable cast-irons that are subject to wear. The effect of free carbide on the machinability and the wearing properties of an iron must therefore be carefully considered.

Fig. 5 shows a series of photomicrographs taken from a step cylinder. That at the left is from a section 1 in. thick that is mostly pearlitic with a few carbide spots, and is readily machinable. The center view is from a section ¼ in. thick, which was machinable with difficulty; the tool dulled quickly, a fact that is easy to explain by the large amount of free carbide present. The right-hand view is from a section ¼ in. thick and shows a white iron that, under ordinary conditions, would dull a tool immediately; the excessive amount of iron carbide is easily apparent. All these changes are produced in the same iron by the effects of different rates of cooling as a result of the varying thickness of the section.

It is evident from the above that, if the discussion is confined to a readily machinable product, the presence of free iron carbide must be limited to a relatively small quantity. The same effect is produced by high phosphorus content resulting in phospho-carbide spots of great hardness.

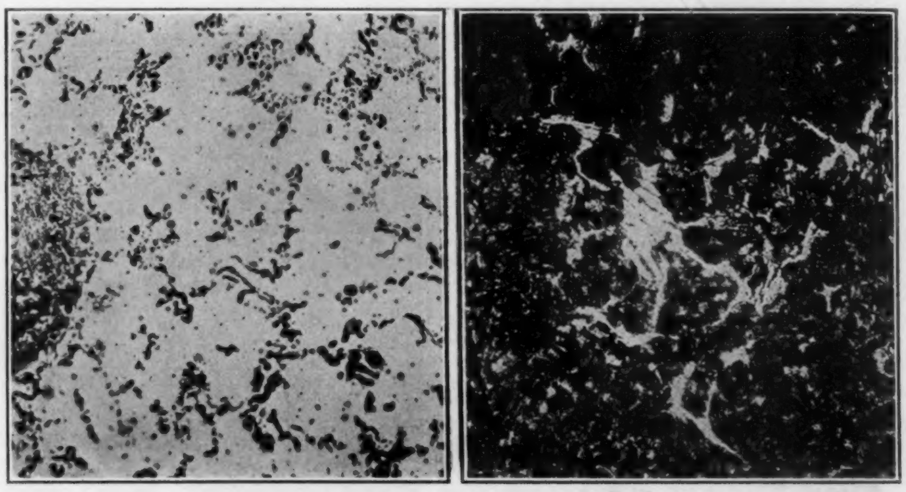


FIG. 2—MICROSTRUCTURE OF CAST IRON *B*

This Iron Has Small Well-Distributed Graphite Flakes, a Matrix Showing Pearlite and Spots of Phospho-Carbides and Free Ferrite. The Dent Shown at the Left Is the Impression Produced by a Shore Hardness-Test

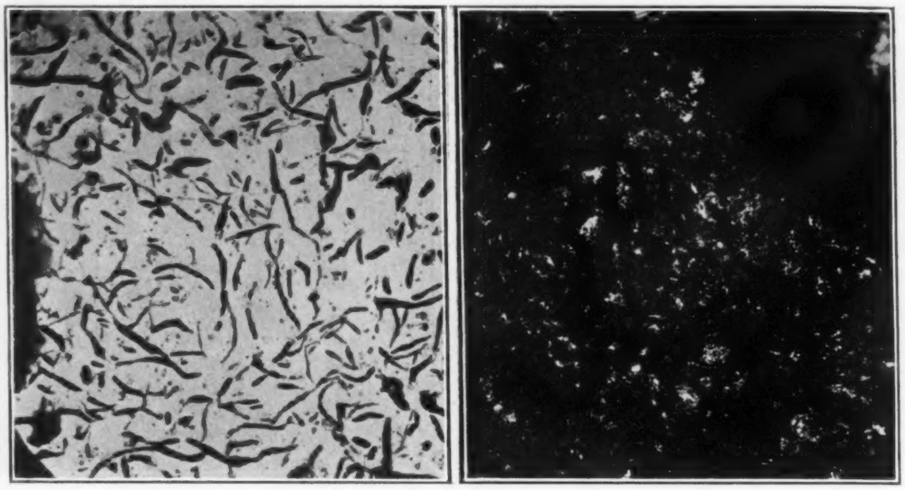


FIG. 4—MICROSTRUCTURE OF CAST IRON *D*

This Iron Contains Medium-Size Graphite Flakes, Practically No Free Cementite and a Small Scattering of Free Ferrite, and the Combined Carbon Is Largely in a Sorbitic State. The Curved Spot at the Extreme Left Is the Impression Created by the 1/16-In.-Diameter Ball Used by the Rockwell Machine, When Using the "B" Scale

The wearing property of white iron is due to the presence of sufficient carbides to provide an almost continuous hard bearing-surface. When the carbide spots that are present constitute only a small percentage of the total area, a different condition exists, namely, that of a few spots of hard material embedded in a softer material. A number of studies[2] on the worn surfaces of iron containing free-carbide or phospho-carbide spots have shown that the softer material wears away, leaving the hard spots standing out in relief on the surface, a condition that would result in rapid wear of the opposing material. Besides being hard, the material in these spots is also brittle and is easily broken loose; it then becomes an abrasive between the two rubbing surfaces and results in scoring-marks. From this the conclusion can be drawn that the smallest possible amount of excess phosphide and carbide content is desirable, not only to make the iron easily machinable but to assure good wearing properties.

MICROCHARACTERISTICS OF GOOD-WEARING IRONS

Considering the characteristics of the various constituents, a good-wearing iron but one that is machinable has the following characteristics:

(1) The presence of well-distributed primary graphite

(2) A sufficient quantity of combined carbon to make the matrix largely pearlitic or, better still, sorbitic in structure

(3) The absence of free carbide and phosphide particles

When these conditions have been met, the increased hardness will indicate improved wearing property, for the increase in hardness will be produced by a change in the matrix that results from an increased quantity of pearlite, or a gradual change to a sorbitic character, and is not due to an increase in the amount of carbide spots. This type of iron is illustrated in the right-hand view of Fig. 6, in Fig. 7, and in the right-hand views of Figs. 8 and 9. Irons having this characteristic structure have proved their good wearing properties, both in wearing-tests and in service in a large variety of applications.

PROPERTIES IMPROVED BY NICKEL AND CHROMIUM

To produce a sorbitic structure on a wearing surface, and ready machinability in other parts, is a problem requiring considerable ingenuity and skill on the part of the foundryman and metallurgist. Various expedients have been used in the foundry to produce this structure, but probably the greatest progress has been made recently by the intelligent addition of nickel and chromium to cast iron. The effect of adding nickel in increasing quantities to cast iron is unique. Its addition will prevent or eliminate free-carbide spots, or white iron, while at the same time it will increase the hardness of the gray portion of the iron due to the formation of sorbite instead of pearlite. The addition of chromium in increasing quantities tends to increase the amount of combined carbon in the finished casting and, if the chromium is used in excess, it will produce areas of free carbide. By using both constituents together in the proper proportions, both elements are made much more effective.

The hardness of a casting originally free from carbide spots may be increased greatly by adding nickel and chromium in the ratio of about 3 parts of nickel to 1 of chromium. The action is somewhat as follows: The chromium

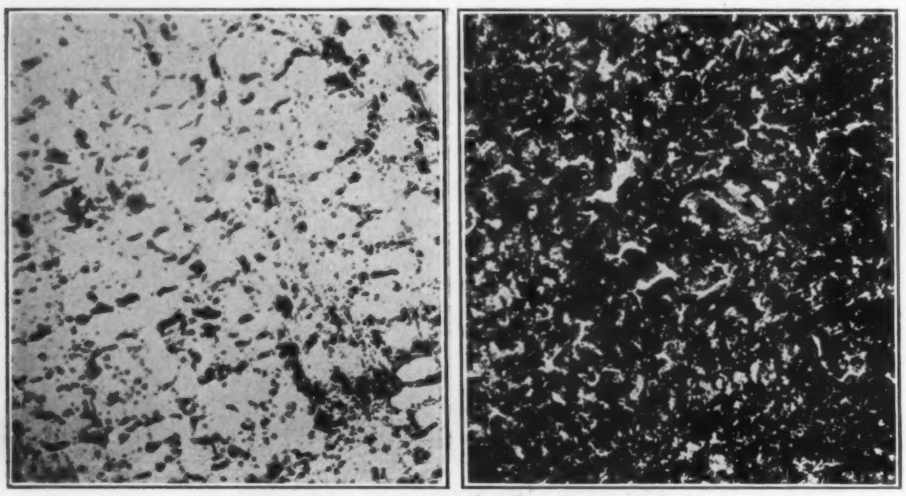


FIG. 3—MICROSTRUCTURE OF CAST IRON *C*

This Iron Is Characterized by Small Graphite Flakes, a Matrix of Pearlite, Free Cementite and Some Ferrite

[2] See An Investigation on the Wearing and Anti-Frictional Qualities of Cast Iron, by J. E. Hurst; The Iron and Steel Institute Carnegie Scholarship Memoirs, 1918, p. 59; also, The Wear of Cast-Iron Cylinders and Liners, *The Iron Age*, June 22, 1916, p. 1492.

increases the normal amount of combined carbon; the nickel prevents the formation of excess-carbide spots, and the nickel and chromium together tend to change the structure of the combined carbon from pearlite to sorbite and, if used in sufficient quantities, to martensite. By changing the ratio, various conditions may be met. If a casting has corners and edges that tend to chill, nickel should be used alone to increase the hardness of the wearing surface; or a higher ratio of nickel to chromium, such as 5 parts of nickel to 1 part of chromium, may be used. In irons that show an excessive amount of free ferrite, as often occurs in slowly cooled castings, a lower ratio of nickel to chromium, such as 2 parts of nickel to 1 part of chromium, might be used safely.

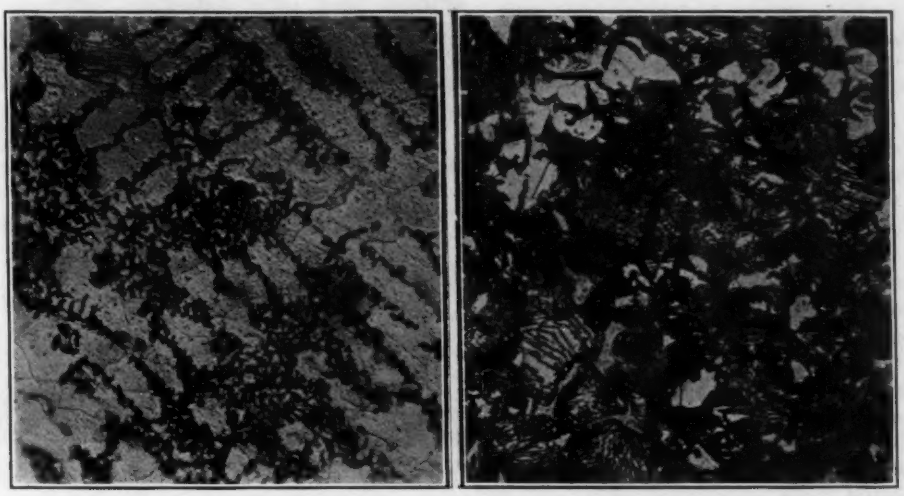


FIG. 6—EFFECT OF NICKEL ON CYLINDER IRON

At the Left Is Shown an Iron the Matrix of Which Contains an Excessive Amount of Free Ferrite, Practically No Combined Carbon as Pearlite, and Some Soft Spots of Phosphide. At the Right, Is Shown the Same Basic Iron After 2 Per Cent of Nickel Has Been Added to It. This Structure Shows a Small Amount of Free Ferrite and a Considerable Amount of Pearlite, Which Caused an Increase of Hardness of from 30 to 40 Points, Brinell, and Corrected the Difficulty Produced by Rapid Wear. The Magnification of Both Views Is 500 Diameters

Observation of the life of a great variety of cast-iron parts shows that, when increased hardness is secured with freedom from free carbides, the wearing properties of an iron improve as the hardness increases; also, that an iron containing appreciable amounts of nickel takes a higher luster when polished than does a plain iron, a fact that undoubtedly aids in its resistance to wear.

Each casting is a problem in itself because of its individual characteristics and the foundry limitations. It is impossible to give a general rule on the procedure necessary to produce this structure in a wearing part. Data covering analyses, together with the results secured in a number of cases, will undoubtedly suggest a possible means of solution of other problems.

How Nickel Affects Cylinder-Blocks

The production of good-wearing machinable cylinder-blocks is of prime importance to the automotive industry. The conditions usually existing in the founding of these castings make their production very difficult. Soft flanges and hard cylinder-barrels and valve-seats are desirable, but the reverse is often produced. The dry sand-cores in the barrel, water-jacket and valve-ports heat up when the molten iron is poured about them, but the low heat-conductivity of dry sand results in the iron around these parts cooling very slowly and tends to produce a soft annealed condition in the adjacent parts, while the flanges, often cast in green sand, cool off more rapidly and tend to chill or form hard spots in the corners and on the edges. By adding proper amounts of nickel, or nickel and chromium, the hardness of the cylinder-walls and of the valve-seats may be increased from 30 to 60 points, Brinell, while the portions subject to rapid cooling may be kept entirely free from hard spots and the entire casting made readily machinable.

Fig. 6, left-hand view, shows the structure secured

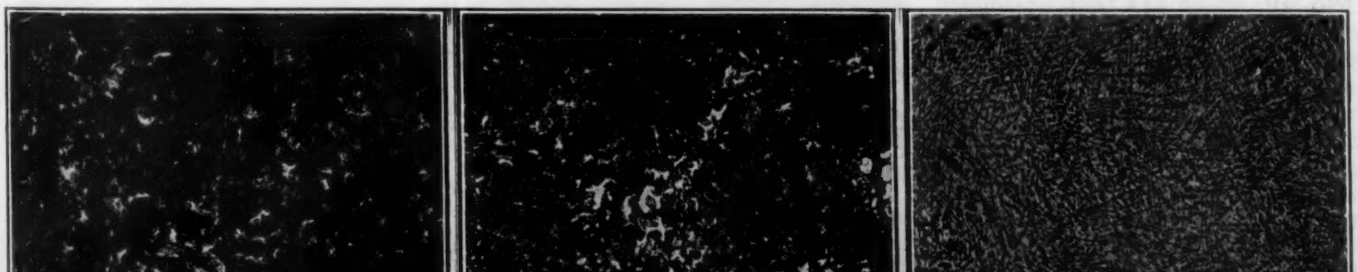


FIG. 5—INFLUENCE OF MICROSTRUCTURE ON THE MACHINING PROPERTIES SOMETIMES FOUND IN A CASTING HAVING SECTIONS OF DIFFERENT THICKNESSES

The 1-In.-Thick Section Shown at the Left Is the Most Pearlitic, with a Few Carbide Spots, and Is Readily Machinable. The 1/4-In.-Thick Section, at the Center, Contains a Large Amount of Free Carbide, Which Causes the Tool To Become Dull Quickly and Is Machinable with Difficulty. The 1/8-In.-Thick Section, at the Right, Shows a White Iron, Mostly Carbide, Which Dulls the Tool Immediately and Cannot Be Machined

in the walls of a cylinder-block in which a great deal of trouble was experienced with excessive wear. The microstructure of the matrix shows an excessive amount of free ferrite, practically no combined carbon as pearlite, and some spots of phosphide. Fig. 6, right-hand view, shows the structure of the cylinder-block after 2.0 per cent of nickel had been added. This structure shows a small amount of free ferrite and a considerable amount of pearlite. A cylinder-block showing this structure resulted in an increase in the hardness of the cylinder-wall of from 30 to 40 points, Brinell, and corrected the difficulty caused by rapid wear.

Fig. 7 shows the structure of a cylinder-block in which the casting conditions were different from those of Fig. 6. Blocks cast under these conditions contained 1.5 per cent of nickel and showed a generous amount of sorbitic pearlite and an average increase of from 30 to 40 points, Brinell, over the plain-iron cylinder-block. Road tests on these blocks have shown less wear after 50,000 miles than plain-iron blocks showed at 25,000 miles.

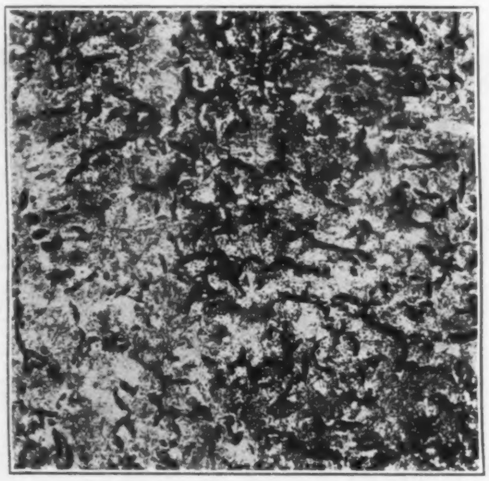


FIG. 7—ANOTHER CYLINDER IRON SHOWING CONSISTENTLY GOOD WEAR

The Casting Conditions of This Iron Were Different from Those of Fig. 6. The Specimen Contains 1.5 Per Cent of Nickel, Has a Sorbitic Pearlite Matrix, and, Having a Brinell-Hardness Number of 190, Shows an Increase of from 30 to 40 Points over That of the Plain-Iron Cylinder-Block. Road Tests of This Block Have Shown Less Wear after 50,000 Miles than Those of Plain-Iron Blocks Showed at 25,000 Miles. The Magnification Is 100 Diameters

The left-hand view in Fig. 8 shows the large quantity of carbide secured by using an excessive amount of chromium in a Diesel-engine cylinder to secure the desired minimum hardness of 200 Brinell. Cylinders and pistons having this structure wore rapidly and showed excessive scoring-marks. The right-hand view in Fig. 8 shows a typical structure secured by adding 2.0 per cent nickel and having very little free cementite. These cylinders have all shown excellent wearing-properties in service.

Variations in hardness in a cylinder-wall are reduced by the addition of alloys, as is illustrated in Fig. 10, which has been assembled from data given by W. E. Day, Jr.[3] The composition of the nickel-chromium iron in cylinder No. 1 and of the plain iron in cylinder No. 2 are given in Table 1.

Traction cylinder-bushings were originally made with an iron containing 2.25 per cent of silicon and the usual range of the other elements. This gave a Brinell hardness of approximately 160. The analysis was changed to 1.90 per cent of silicon, and 1.25 per cent of nickel was added. This increased the Brinell hardness of the cylinder-wall to approximately 200, but the machining-time was decreased because of the freedom from hard spots. An engine equipped with two sleeves of plain iron and two of nickel iron was operated for a distance of about 40,000 miles. Several measurements showed the average wear on the plain-iron liners to be 0.009 and 0.011 in. and on the nickel-iron liners to be 0.003 and 0.004 in.

Air-cooled motorcycle cylinders, after the addition of 0.75 per cent of nickel and 0.35 per cent of chromium, gave an average increase in hardness of 30 points, Brinell, and could be machined as rapidly as those of plain iron; and the life of the engines was doubled.

Table 2 is a list of analyses of some of the nickel-chromium irons now entering into the production of cylinders for automobile engines.

Numerous tests could be cited of the time required to machine plain-iron cylinders in comparison with that of nickel-iron cylinders the walls of which had a Brinell hardness from 30 to 40 points

TABLE 1—VARIATION OF BRINELL HARDNESS IN CYLINDER-WALLS

Element	Composition No. 1, Per Cent	Composition No. 2, Per Cent
Combined Carbon	0.540	0.340
Total Carbon	2.920	3.250
Phosphorus	0.307	0.338
Sulphur	0.060	0.100
Silicon	2.440	2.450
Manganese	0.440	0.620
Nickel	1.310	0.000
Chromium	0.510	0.000

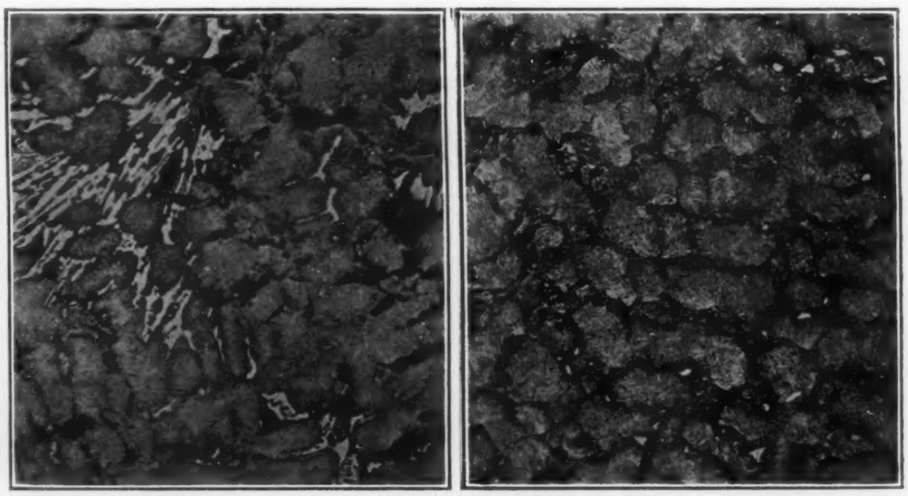


FIG. 8—MICROSTRUCTURE OF A DIESEL-ENGINE CYLINDER-LINER

The Iron Shown at the Left Wore Rapidly by Scoring Because of the Large Quantity of Carbides Present Due to Using an Excessive Amount of Chromium To Produce the Minimum Desired Hardness of 200 Brinell. The Typical Structure Shown at the Right Contains 2.0 Per Cent Nickel, Has Very Little Free Cementite, and Shows Excellent Wearing Properties. The Brinell Hardness-Number of the First Specimen Is 212, That of the Second, 220. Their Magnification Is 100 Diameters

[3] See discussion of paper on Nickel and Nickel-Chromium in Cast Iron, *Transactions of the American Foundrymen's Association*, vol. XXXIII, p. 424.

TABLE 2—ANALYSES OF NICKEL-CHROMIUM IRONS USED IN CYLINDER-BLOCKS

Range of Content of Elements, Per Cent

Engine Bore, In.	Total Carbon	Combined Carbon	Silicon	Manganese	Phosphorus	Sulphur	Nickel	Chromium
3⅛	3.20-3.40	0.40-0.50	1.80-2.00	0.40-0.50	Under 0.20	Under 0.10	1.25-1.50	0
3⅝	3.20-3.40	0.35-0.45	2.30-2.50	0.50-0.60	Under 0.30	Under 0.12	1.00-1.25	0.45
5	3.20-3.40	0.40-0.50	1.75-2.00	0.50-0.60	Under 0.30	Under 0.12	1.25	0
4½	3.20-3.40		2.35-2.50				0.80-1.00	0.35-0.40
3¼	3.40-3.50		2.40-2.55	0.60-0.70	Under 0.50	Under 0.10	2.25-2.50	0
4½ and 5	3.20-3.35	0.35-0.45	2.35-2.55	0.60-0.80	Under 0.20	0.08-0.12	1.25-1.50	0.35-0.45
5	3.20-3.30	0.40-0.50	2.40	0.40-0.50	Under 0.30	Under 0.10	1.30	0.51
3 and 3¼	3.43		2.11			0.095	0.51	0.25
	3.20-3.30		1.90-2.10				0.75	0.25
3¼	3.40	0.50-0.60	2.15-2.30	0.65-0.70	0.18-0.22	0.08-0.09	0.70-0.80	0.30-0.35

higher. In many cases the time of machining has been reduced and the tool life has been greatly increased because of the absence of free-carbide spots in the rapidly cooled sections. When no machining difficulties were present originally, the harder iron could be machined at the same production-rate as the softer iron, and with equal tool-life.

A number of other engine-wear tests could be mentioned showing improvements of from 50 to several hundred per cent in the life of the cylinders by increasing the hardness, with freedom of carbide spots, by the use of nickel.

Hardness Needed To Resist Ring Pressure

Cylinder wear is so intimately related with lubrication that an alloy iron cannot be regarded as a cure for all cases of rapid wear. It is probable that, in the case of cylinders, a great divergence of opinion exists on the value of hard iron for improving the wearing-property. It has been argued that the extensive use of aluminum pistons makes a hard cylinder unnecessary. An examination of worn cylinders, however, will show that nearly all the wear is opposite the piston-ring travel. This is to be expected, as the maximum unit side-wall pressure of the piston itself is comparatively low, being a matter of from 15 to 20 lb. per sq. in., whereas the wall pressure of a close-fitting top-ring temporarily equals the full explosion-pressure in the combustion chamber, a pressure of from 300 to perhaps 400 lb. per sq. in. To secure the necessary springiness in a ring, the hardness must be fairly high.

A number of tests have shown a range of from 45 to 55 Shore, corresponding to a Brinell hardness of from 235 to 260; and the microstructure invariably shows considerable free cementite. When a cylinder-wall has a hardness of only 150 to 160 Brinell, the difference is so great that the ring may act as a cutting-tool, especially if it tends to cock slightly and exposes a sharp edge. Accelerated wear-tests show that, when two irons are of widely different degrees of hardness, the softer iron wears very rapidly; whereas, two irons of approximately the same hardness show much greater resistance to wear. Hence, it is desirable that the cylinder-walls should have high Brinell hardness.

The desirability of high hardness is not confined to the cylinder-walls alone, because, with the high engine-speeds used today, considerable trouble is experienced with the pounding of valves into their seats. I have the testimony of the engineers of four companies that the use of iron having higher hardness, produced by the addition of nickel or nickel and chromium, has eliminated all trouble from this source.

Another advantage that has been noted in alloy-iron cylinders over those of plain iron is greater freedom from warpage. This is probably connected with the more uniform structure to be found throughout the casting, which would not be subject to the casting strains found in a casting having a wide difference in structure.

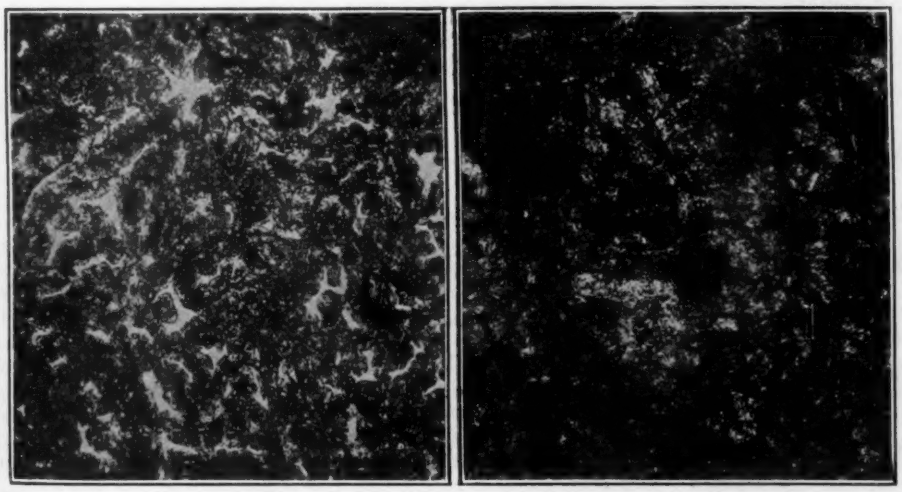


Fig. 9—Microstructure of Iron Used in Brake Drums

The Iron Shown at the Left Did Not Wear Rapidly but Scored on the Surface and Tore the Brake Lining. The Addition of 1.0 to 5.0 Per Cent of Nickel Assures Freedom from Carbide Spots and Gives Even and Smooth Wear. In the View at the Right, the Desired Microstructure of Iron Suitable for Brake Drums and Clutch Plates Is Shown. The Brinell Hardness of the Iron at the Left Is 180; of That at the Right, 200. The Magnifications Are, Respectively, 75 and 250 Diameters

Some of the problems confronting the manufacturer of cast-iron pistons are that the pistons tend to chill white at the bottom of the piston-skirt. If an iron sufficiently high in silicon is used to overcome this difficulty, the pistons tend to have excessive shrinkage in the boss. An iron sufficiently low in silicon to overcome the shrinkage in the boss is commonly used and the casting is then annealed at from 1400 to 1500 deg. fahr. to make the bottom of the skirt machinable. This procedure will produce an iron that is very soft and has low strength. Unless it is handled carefully, the finished casting may easily be given a permanent set. The soft casting also wears rapidly. To overcome this condition, from 0.50 to 1.00 per cent of nickel is added to a lower-silicon iron. This eliminates the chill at

the bottom of the skirt, making the casting machinable without high annealing. By heating the casting to 900 or 1000 deg. fahr., which does not soften it but relieves any casting strains, a casting is secured that can be held to very close limits and is not easily sprung out of shape. The iron used by one manufacturer before using nickel contained from 2.60 to 2.75 per cent of silicon. This was reduced to from 2.40 to 2.55 per cent, when from 0.80 to 1.00 per cent of nickel was added.

Similar conditions are found in valve guides. The use of nickel iron of approximately the above analysis results in a guide that can be easily machined without annealing and gives improved wear.

Brake Drums and Clutch Plates

Usual operations of these parts make them a wear-testing machine. The experience of one motorcoach-operating company with clutch plates is as follows: The life of plates made of ordinary gray-iron on 300 motorcoaches has been from 2 to 3 weeks. These plates show a Brinell hardness of 196. Cast-steel plates having a Brinell hardness of 122 had to be removed in 2 weeks. An annealed hard-iron having a Brinell hardness of 204 but showing considerable excess cementite had to be removed in about 6 weeks. The plates warped badly and the projecting carbide-spots invariably tore the asbestos lining to pieces. Plates made of a special iron showing 203 Brinell, and the microstructure of which showed it to be free from carbide spots, have been in service 5 months and are still in use.

Experience has been similar on brake drums of hard iron produced by adding from 1.00 to 5.00 per cent of nickel, which assures freedom from carbide spots and gives even and smooth wear. Because of the uniformity of the combined carbon in different sections, the brake drums showed even heat-distribution and resisted warpage. Fig. 9 illustrates the desired microstructure of iron suitable for this purpose.

Dies and Cams

Irons of from 240 to 260 Brinell, containing from 3.00 to 3.40 per cent of carbon, the silicon varying with the thickness of the casting but being generally from

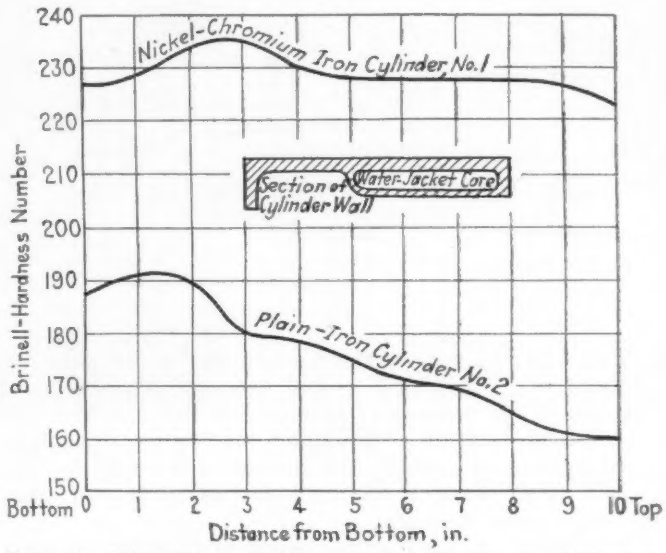


FIG. 10—VARIATION OF BRINELL HARDNESS IN CYLINDER-WALLS

The Hardness Has Been Found To Be Reduced by Alloys, as Is Indicated by the Data Given in Table 1

1.20 to 1.40 per cent, and having 3.00 to 4.00 per cent of nickel alone, or, on heavy work, 3.00 per cent of nickel and from 0.60 to 0.90 per cent of chromium, produce an iron of the above hardness in sections up to 2 in. that are machinable without difficulty. This iron, when used on dies, cams and similar applications, has shown an increase in life from 5 to 10 times that which has been possible with other irons or with hard-steel dies.

Acknowledgments

Grateful acknowledgment is given to the personnel of the research laboratory of the International Nickel Co., at Bayonne, N. J., for the preparation of the samples and many of the photomicrographs. Numerous engineers and metallurgists connected with the automotive industry have supplied many of the data given. It is only at their request that I refrain from mentioning them personally.

Road Planning for Traffic Relief

At present the tendency is for big cities to concentrate their distributing center for passenger traffic at one point. This at once leads to congestion, and it would be far better to split them up into four points, north, east, south and west, distributing respectively to the four quarters of the town. Near-by each of these centers should be a private-car park. Once these facilities are provided, parking of cars in streets should be prohibited. Through traffic, in what has hitherto been a congested area, would be facilitated and the death roll due to accidents considerably reduced.

Where a city is not yet fully laid out, the matter requires very careful consideration. The system of laying the streets out in squares is admirable for traffic travelling north, east, west or south, but extremely difficult for traffic travelling at an angle to any of these points. Nor does a system of circles satisfy the requirements of vehicles travelling in all directions. It is obvious that a combination of these two systems and of diagonal streets tends to more ideal conditions.

In suburban areas where building is in progress certain definite rules should be laid down. The exits to all side streets should be either bell-mouthed or, at any rate, made one and a half to two times the width of the remainder of the street. The residential or dormitory area should not be built along the main roads but in districts between.

As we get further away from the town, the layout of the roads can be more freely developed. Every side road, when entering into a main road, should be double its width for at least 200 yards before the junction. This will allow traffic to continually trickle through and, if there are two side roads entering into the main road at the one point, will allow two streams of traffic to get away when the signal is given.

Cross roads should be avoided as much as possible, but where they exist an automatic signal should be installed. A refuge should also be provided, as children would soon learn they should cross only when the green light shows in their direction.—Major R. A. B. Smith, in a paper presented at the World Motor-Transport Congress.

Motor-Oil Characteristics and Performance at Low Temperatures[1]

By R. E. Wilkin,[2] P. T. Oak[3], and D. P. Barnard, 4th[4]

Annual Meeting Paper

Illustrated with Charts, Drawing and Photograph

RESULTS of an experimental study of the viscosity characteristics of motor oils at low temperatures and their influence upon cranking torque and circulation within the engine are presented by the authors.

At temperatures in the neighborhood of 0 deg. fahr., even oils of asphaltic origin appear to possess some plastic characteristics, while those of the mixed and paraffin-base types deviate widely from the generally accepted laws of viscous flow. Oils of these latter classes have apparent viscosities which tend to increase with decreasing shearing-stress and to become somewhat greater than might be expected from a study of their characteristics at normal temperatures. However, as resistance to cranking the engine is due mainly to oil in thin films on the cylinder-walls, the relatively small temperature-viscosity coefficient of the wax-bearing oils gives them a marked advantage over those of asphaltic origin, an advantage which becomes greater as the temperature is lowered.

Circulation tests in an engine equipped with a comparatively small-mesh screen over the pump intake indicated that circulation was not obtained until the oil in the sump attained its "pour-point" temperature. In general, the work indicates that a low-temperature viscosity coefficient is highly desirable to minimize cranking effort, and that free circulation requires an oil the effective viscosity of which does not increase too rapidly at very low shearing-stresses.

THE increasing winter use of automobiles has necessitated a much more careful analysis of the factors affecting the ease of starting and the effectiveness of the lubricating systems under cold-weather conditions than was formerly necessary. Some phases of this problem have been worked out in detail and the results published. For example, the Bureau of Standards, in the paper on Fuel Requirements for Engine-Starting[5], by C. S. Cragoe and J. O. Eisinger, presented a complete survey of the effect of the volatility of the motor fuel in determining the ease of starting and the acceleration at low temperatures. Papers on Cylinder and Engine Lubrication[6], by A. L. Clayden, and on A Suggested Remedy for Crankcase-Oil Dilution[7], by R. E. Wilson and R. E. Wilkin, as well as others, present analyses of the causes and effects of dilution, including its value in facilitating cranking.

Low-temperature characteristics of starting systems have also been carefully worked out. Practically nothing has been published, however, on the remaining important problem; namely, the effect of the low-temperature viscosity of the oil and its pour-test on engine performance at low temperatures. Indeed, apparently very little has been done on the rather difficult problem of measuring the low-temperature viscosity of motor oils, the outstanding exception being the work of Parsons and Taylor, who published, in their paper on Lubricating Value as Related to Certain Physical and Chemical Properties of Oil[8], the results of some experimental work in which the viscosity characteristics of two widely varying types of oil, asphalt and paraffin-

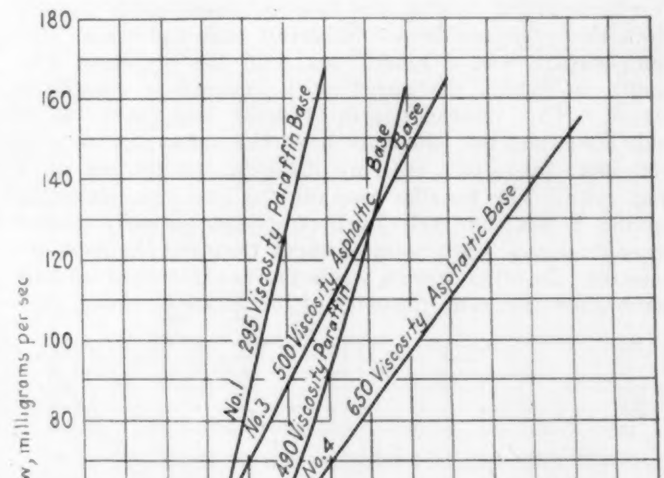


Fig. 1—Typical Flow versus Pressure-Drop Curves

The Curves Are for Paraffin-Base and Asphalt-Base Oils as Determined by Parsons and Taylor. The Rate of Flow of the Oils Through a Standard Saybolt Universal Viscosimeter at 0 Deg. Fahr. Is as Follows:

Oil No.	Viscosity in Saybolt Sec. at Deg. Fahr. 100	210	Pour-Point, Deg. Fahr.
1	295	52	35
2	490	63	35
3	500	55	5
4	650	61	0

[1] Contribution from the engine laboratory of the Standard Oil Co. of Indiana, Whiting, Ind.

[2] M.S.A.E.—Chemical engineer, Standard Oil Co. of Indiana, Whiting, Ind.

[3] Research engineer, Standard Oil Co. of Indiana, Whiting, Ind.

[4] Research engineer, Standard Oil Co. of Indiana, Whiting, Ind.

[5] See The Journal, March, 1927, p. 353.

[6] See The Journal, July, 1925, p. 58.

[7] See The Journal, February, 1926, p. 163.

[8] See *Industrial and Engineering Chemistry*, May, 1926, p. 493.

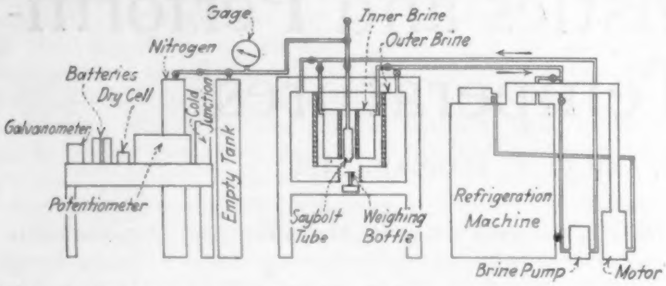


FIG. 2—DIAGRAMMATIC REPRESENTATION OF THE VISCOSIMETER

The Equipment Is Designed for Work at Low Temperatures. It Consists of a Saybolt Universal Jet Fitted to a Reservoir Approximating the Saybolt Instrument in Dimensions and Cooled by a Brine System as Illustrated

base, were compared at low temperatures and under varying heads. A Saybolt viscosimeter tube was used in this work, air pressure being employed to furnish the head necessary to produce the required rate of flow. Their results are illustrated in Fig. 1, in which the rate of flow observed has been plotted against the corresponding pressure-drop.

It will be noticed in the results shown that the asphalt-base oil apparently conformed to Poiseuille's law in that the flow varied directly as the pressure-drop. The paraffin-base oil, however, showed an entirely different behavior in that the flow increased more rapidly than the pressure-drop, indicating that the oil at this temperature was a plastic material the apparent viscosity of which decreased with increasing shearing-stress. This characteristic is most important, as it indicates that two oils may have the same viscosity at 100 deg. fahr. but entirely different properties at 0 deg. fahr. The paraffin-base oil, for instance, although having a comparatively high pour-test, actually flowed more readily at high rates of shear than did the asphalt-base oil. In other words, while the paraffin-base oil had the higher apparent viscosity at low rates of shear, this

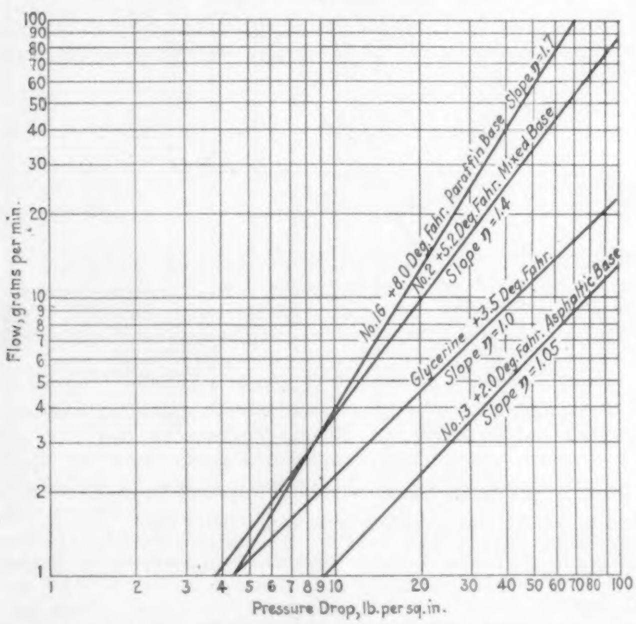


FIG. 3—LOGARITHMIC FLOW VERSUS PRESSURE-DROP CHART

The Chart Is for Oils of the Three Principal Classes. The Characteristics of Glycerin are Included for Purposes of Comparison. The Logarithmic Scale Was Used Instead of Arthmetical Coordinates To Afford Constant Precision in Plotting and To Cover a Wider Range of Observations

condition was reversed at high rates of shear. Parsons and Taylor did not, however, describe any correlation between these results and actual engine-performance.

PURPOSE OF OBTAINING THE DATA

The data reported herein were obtained in an effort to answer the following specific questions:

(1) What is the magnitude of the differences between the viscosity-temperature curves of different types of oil at low temperatures?
(2) What is the relative importance of low-temperature viscosity and pour-test in determining the ease of starting of an engine in cold weather?
(3) What is the relative importance of the two properties in determining oil circulation within the lubricating system of the engine?
(4) How does the apparent viscosity of oils at low temperatures vary with the shearing stress applied, and at what rates of shear should the apparent viscosity be determined to measure the effective viscosity of the oil in the engine?

LOW-TEMPERATURE VISCOSITY DETERMINATION

To simplify both experimental procedure and interpretation of results, the same general method was employed for determining low-temperature viscosities as that used by Parsons and Taylor, the use of a Saybolt viscosimeter under pressure. The apparatus used consisted of a Saybolt universal jet fitted to a reservoir approximating the Saybolt instrument in dimensions and cooled by a brine system, as illustrated diagrammatically in Fig. 2. A small thermocouple was inserted to measure the temperature of the oil just before it entered the metering capillary. This was connected to a Type-K Leeds & Northrup potentiometer which permitted temperatures at this point to be determined to within 0.1 deg. fahr. It is felt that this system was more accurate and reliable than that of the "dummy" tube immersed in a freezing mixture, as was used by Parsons and Taylor. Due to the fact that the viscosity of practically all oils doubles for temperature-drops of 5 to 10 deg. fahr. in the neighborhood of zero, accuracy of temperature determination is most important.

The procedure followed consisted simply in filling the viscosimeter tube with the oil to be examined, allowing it to cool for several hours, usually over night, and weighing the oil discharged in say 30 sec. under the pressure-head used, the temperature of the oil just above the capillary being recorded as a part of each observation. The amount of oil discharged for determination varied considerably but, as a rule, was at least 4 grams to minimize errors due to variations in the amount adhering to the viscosimeter tip after flow had been stopped. The three-way control-valve permitted rapid release of pressure from the viscosimeter tube and greatly facilitated accurate timing. The observed flow-rates were converted to Saybolt seconds by means of the formula:

$$\text{Saybolt Seconds} = \frac{31{,}500 \times \text{Pressure-Drop Including Gravity Head in Pounds per Square Inch}}{\text{Flow in Grams per Minute}} \quad (1)$$

Equation (1) assumes that the flow is directly proportional to pressure, which is frequently not true; so the result does not represent the time that would be required for the flow to take place without any external pressure, but gives a figure for the *apparent* viscosity of the oil in familiar units.

The results obtained by this method are illustrated by Fig. 3, in which the rates of flow as observed have been

plotted against the pressure-drop for three typical oils. The logarithmic scale was used in this work instead of arithmetical coordinates, as employed by Parsons and Taylor, to afford constant precision in plotting and to cover a wider range of observations. On such a plot any fluid which follows the laws of viscous flow, or flow directly proportional to pressure, will give a straight 45-deg. line having a slope of 1. However, none of these oils showed such a slope at the lower temperatures indicated.

The deviation in the case of the asphalt-base oil was not great, but in the other two it was marked, the flow increasing more rapidly than in proportion to the pressure. The data for glycerin have been included for the purpose of demonstrating that the nonconformity with Poiseuille's law was not an apparatus characteristic. The same data plotted as apparent viscosity versus pressure-drop are shown in Fig. 4. The slopes of these graphs become equal to $1-\eta$, where η is the slope of the lines in Fig. 3.

Departure from Laws of Viscous Flow

The departure from the ordinary laws of viscous flow, as illustrated in Figs. 3, 4 and 5, is typical of the different classes of oils examined. It is evidently due to the presence of a colloidal structure which becomes more pronounced as the temperature is lowered. In the case of the paraffin-base oils the solid phase is undoubtedly mainly wax crystals, but some kind of colloidal particles also appear to be present in the asphalt-base oils.

Fig. 5 shows the results of a number of observations at different temperatures for oils of different viscosities belonging to the three general types. It was observed throughout this work that η is rather erratic, although variations were never so great as to cause overlapping of oils of the different classes. It is probable that deviation of η from unity is in some way related to the pour-test temperature as specified by the American Society for Testing Materials, but the data available at present do not indicate the existence of any definite relation and evidently the deviation certainly persists well above the pour-point. Furthermore, there seems to be no direct bearing of viscosity, within the limits examined, upon the value of η. In general, this work can be summarized in accordance with Table 1.

[10] See Hydrodynamics, by E. Lamb, 1924 edition, p. 554.

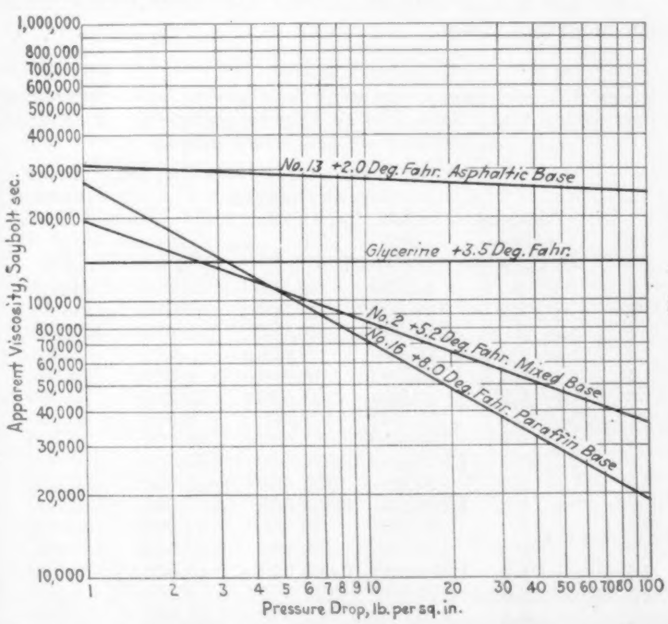


FIG. 4—LOGARITHMIC VISCOSITY VERSUS PRESSURE-DROP CHART OF DATA GIVEN IN FIG. 3

The Slopes of These Graphs Become Equal to $1-\eta$, Where η Is the Slope of the Lines in Fig. 3

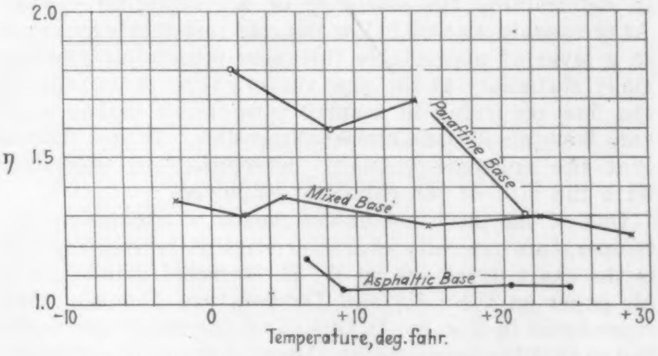


FIG. 5—VARIATION OF η WITH TEMPERATURE

The Slope of the Curves Plotted as in Fig. 3 Is Represented by η. The Results of a Number of Observations at Different Temperatures Are Shown for Oils of Different Viscosities Belonging to the Three General Types

TABLE 1—SUMMARY OF RESULTS OF OBSERVATIONS AT DIFFERENT TEMPERATURES FOR OILS OF DIFFERENT VISCOSITIES BELONGING TO THE THREE GENERAL TYPES

Oil No.[a]	Viscosity in Saybolt Sec., at Deg. Fahr. 100	210	A. S. T. M. Pour-Point, Deg. Fahr.	Value of n Pour-Point	0 Deg. Fahr.
1	216	45	+ 3	1.1	1.1
2	331	50	+ 23	1.3	1.3
3	565	61.5	+ 40	...	1.3
4	109	41	— 7	...	...
5	185	46.5	— 5	1.2	1.2
6	205	46.5	+ 10	1.1	1.1
7	390	57	+ 25	1.15	1.2
8	1,165	94	+ 40	...	...
9	...	161	+ 40	...	...
10	325	51	+ 45	...	...
11	565	62	+ 45	...	...
12	308	48	0	...	...
13	580	56	0	1.15	1.15
14	1,080	70	+ 10	...	...
15	130	42	+ 45	...	2.4
16	231	51	+ 40	...	1.8
17 (a)	2,064	148	+ 45	1.3	...

[a] The numbers of the oils are consistent throughout the paper.

Inasmuch as the A. S. T. M. pour-test is substantially a determination of the temperature at which the apparent viscosity becomes infinite under the existing conditions of very low shearing-stress, it is to be expected that, if the foregoing work be extended to include very small pressures, a bend in the curves shown in Figs. 3 and 4 would result. An example of one such series of observations is given in Fig. 6. The upward curvature of the apparent viscosity-pressure-drop curves can be taken as indicating the increase in shearing stress necessary to overcome the solid structure, or solid-test effect, in the oil at the temperature noted. The solid-test effect is apparently distinct from the remainder of the pressure-viscosity graph. Fig. 6 shows also how the variations in apparent viscosity disappear as the temperature is raised.

Variation of η from unity has a pronounced influence upon the flow characteristics of an oil. If the fundamental equation[10] for the velocity distribution for viscous flow in a circular pipe be modified in accordance with this variable viscosity-effect, the velocity distribution takes the form indicated in Fig. 7. The net effect

is that of a reduction in passage area and is important in determining the efficiency of a circulating system. At temperatures well below the cold test this may result in a layer of appreciable thickness remaining substantially stationary at the pipe surface with practically all the flow occurring in a small core, which makes accurate flow-calculations almost impossible. It also follows that the apparent viscosity determinations will vary with the size of the capillary employed.

One of the most convenient means of expressing the temperature-viscosity characteristics of lubricating oils is the chart developed by W. H. Herschel, published in his paper on Viscosity and Temperature Changes[11], and reproduced in Fig. 8. In this chart the scales are modified so that the temperature-viscosity graph is a straight line, at least at normal temperatures. If the graph obtained by plotting the viscosities at say 210 deg. fahr. and 100 deg. fahr. be extended to 0 deg. fahr., the viscosity indicated at this last temperature is presumably that of a true liquid free from pour-test or other plastic effects. In the case of oils having values of η greater than unity it is to be expected that observed viscosities will be higher than would be indicated by the chart unless the shearing stress be large enough to overcome completely the effects of any plastic or semi-solid-structure formation. The actual curves indicate that this assumption is approximately correct, apparent viscosities at low rates of shear being much higher than the extrapolated straight line. The magnitude of the deviations is rather minimized by the highly compressed scale employed, but will be evident by referring to the figures on the ordinates.

[11] See *Oil and Gas Journal*, Dec. 2, 1926, p. 146.

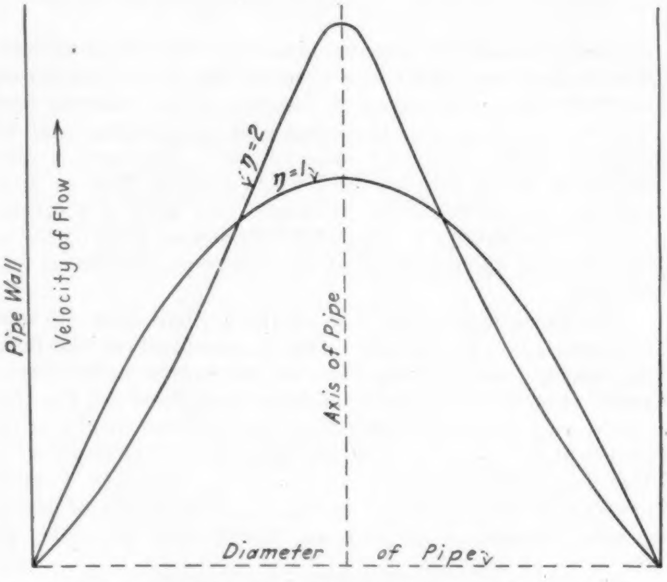


Fig. 7—Typical Velocity-Distribution Curves for Viscous Flow in a Circular Pipe

The Curves Show the Effect of Deviation from the Simple Laws of Fluid Flow. The Net Effect Is That of a Reduction in Passage Area and Is Important in Determining the Efficiency of a Circulating System

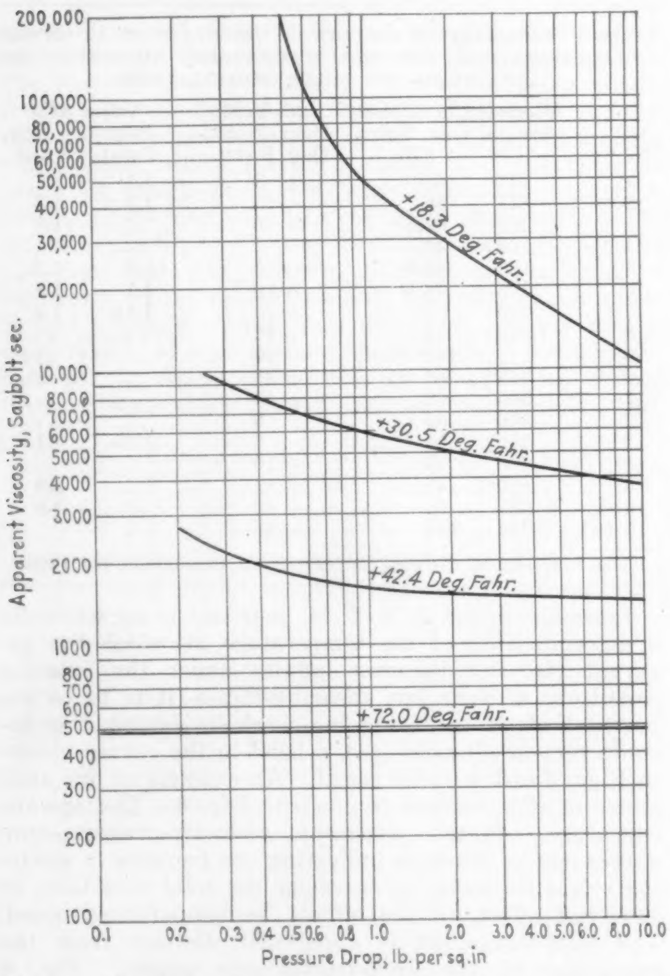


Fig. 6—Viscosity Characteristics of a Paraffin-Base Oil at Low Shearing-Stresses

The Tendency To Solidify Due To Wax Separation Is Clearly Evident. The Upward Curvature of the Curves of Apparent Viscosity versus Pressure-Drop Can Be Taken as Indicating the Increase in Shearing Stress Necessary To Overcome the Solid Structure, or Solid-Test Effect, in the Oil at the Temperature Noted

Comparison of Viscosities

Table 2 presents a comparison between the viscosities as predicted from inspection data at 100 deg. and 210 deg. fahr. by means of extrapolation on the Herschel chart and actual determinations for several conditions of shearing stress.

TABLE 2—COMPARISON BETWEEN VISCOSITIES PREDICTED FROM INSPECTION DATA AND ACTUAL DETERMINATIONS FOR SEVERAL CONDITIONS OF SHEARING STRESS

		Apparent Viscosity, in Saybolt Sec. at Pressures of			From Herschel Chart, Saybolt Sec.
Oil No.[12]	Temperature, Deg. Fahr.	5 Lb. per Sq. In.	10 Lb. per Sq. In.	200 Lb. per Sq. In.	
1	+ 1	42,000	39,300	30,000	45,000
2	+ 2.1	149,000	120,000	49,300	60,000
3	+ 3	519,000	420,000	169,000	123,750
4	— 2.2	10,500	7,600	.....	7,400
5	+ 0.3	21,200	18,000	8,500	15,000
6	+ 0.3	40,000	25,000	19,200	19,000
7	— 0.6	158,000	138,000	78,000	46,000
8	+ 19.9	550,000	355,000	56,000	75,000
9	+ 27.3	1,870,000	1,370,000	355,000	252,000
10	+ 2.1	530,000	335,000	45,000	80,000
11	+ 3.6	1,480,000	1,300,000	220,000	116,500
12	0	92,000	90,000	84,000	100,000
13	0	540,000	490,000	322,000	450,000
14	+ 1.6	1,500,000	1,360,000	910,000	1,575,000
15	+ 2.6	271,000	122,000	3,800	3,900
16	— 0.5	410,000	252,000	31,000	52,000
17 (a)	+ 24.3	700,000	530,000	160,000	90,000

[12] The numbers of the oils are consistent throughout the paper.

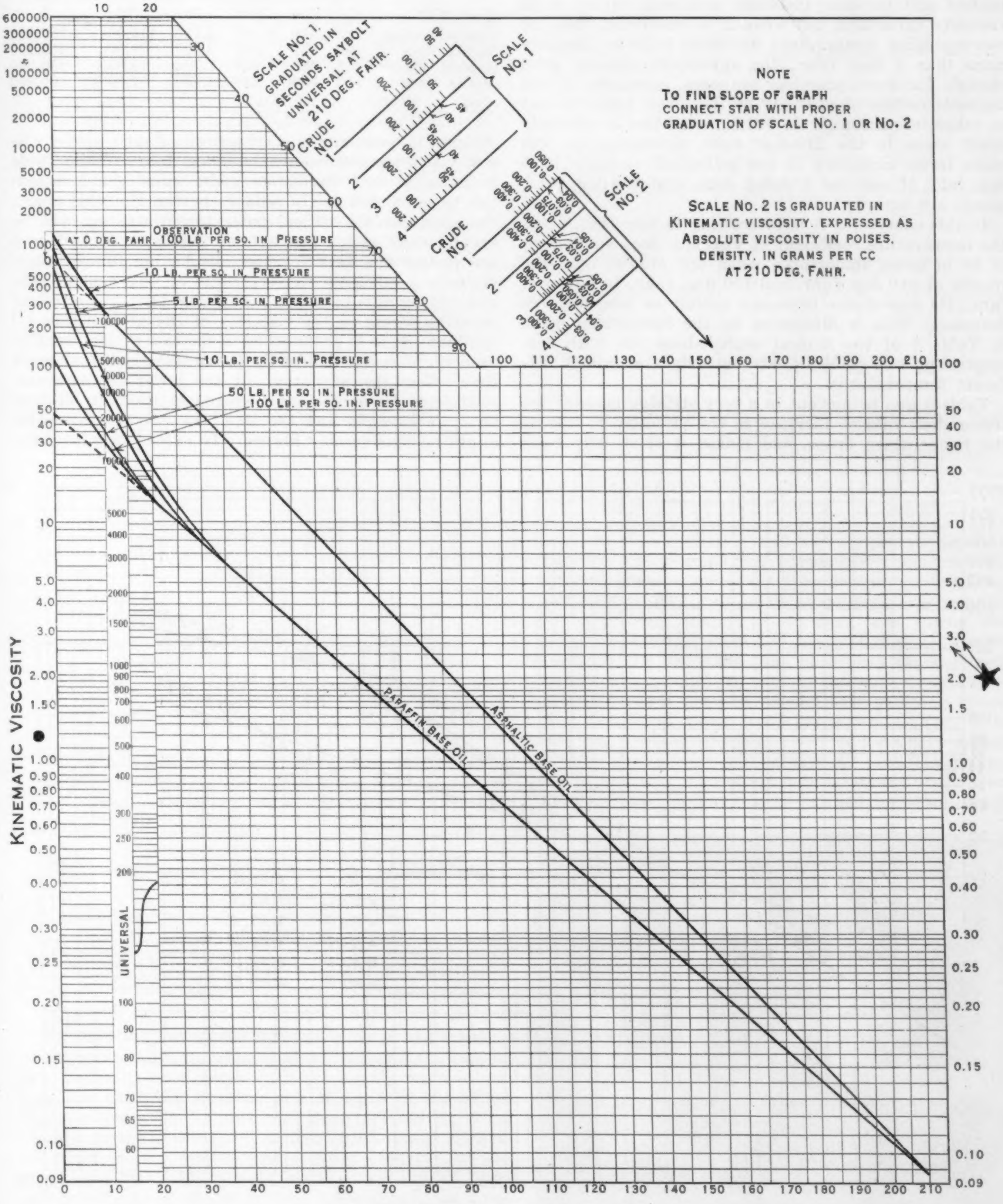


Fig. 8—Viscosity-Temperature Chart Arranged by Herschel

The Data Shown Are for Paraffin-Base and Asphalt-Base Oils. The Scales Are Modified So That the Temperature-Viscosity Graph Is a Straight Line, at Least at Normal Temperatures

Evidently, best agreement between estimated and observed viscosities is obtained under a pressure-drop of about 200 lb. per sq. in. The checks are by no means perfect and in some instances represent rather large viscosity variations, but when it is considered that the corresponding temperature deviation is in no instance more than 5 deg. fahr., the agreement appears good enough for most practical purposes, especially if the unstable nature of viscosity at the lower temperatures be taken into account. It will be noted that a relatively small error in the 210-deg. fahr. determination will make large variations in the estimated viscosity at 0 deg. fahr. if only the 210-deg. fahr. and 100-deg. fahr. points are known.

In this connection it is interesting to note that, while the temperature coefficient of viscosity does not appear to be of great importance when one studies only the results at 210 deg. fahr. and 100 deg. fahr., or 130 deg. fahr., its importance increases rapidly as temperatures decrease. This is illustrated by the comparison made in Table 3 of two typical asphalt-base oils with corresponding oils of Mid-Continent origin at widely different temperatures.

Table 3 also brings out in a very striking manner the tremendous rate of increase in the viscosity of oils as the temperature drops, and makes it clear why some dilution is necessary to start any oil of satisfactory viscosity at temperatures around 0 deg. fahr. While Table 2 indicates that viscosities under considerable stress can be estimated fairly reliably by the Herschel chart, the apparent viscosities under lower stresses will be greater than such a prediction. For example, in Fig. 8 are plotted the data for two oils having temperature-viscosity coefficients characteristic of (*a*) asphalt-base and (*b*) paraffin-base oils. At 0 deg. fahr. the effect of shearing stress on the viscosity of the asphalt-base oil is slight. It is so pronounced in the case of the paraffin-base oil, however, that at the lower stresses it may more than offset the advantage of the lower temperature-coefficient. Under the rapid-shear conditions in oil-films on cylinder-walls and the like, the effective viscosity might be considerably higher. To extend this informa-

TABLE 3—COMPARISON OF TWO TYPICAL ASPHALT-BASE OILS WITH CORRESPONDING OILS OF MID-CONTINENT ORIGIN AT WIDELY DIFFERENT TEMPERATURES

Kind of Oil	Viscosity in Saybolt Sec. at, Deg. Fahr. 210	130	100	70	32	0
Asphalt Base	80	490	1,500	6,700	115,000	4,000,000
Mixed Base	80	375	920	3,000	26,000	360,000
Asphalt Base	55	205	525	1,700	15,000	280,000
Mixed Base	55	180	418	1,150	7,300	66,000

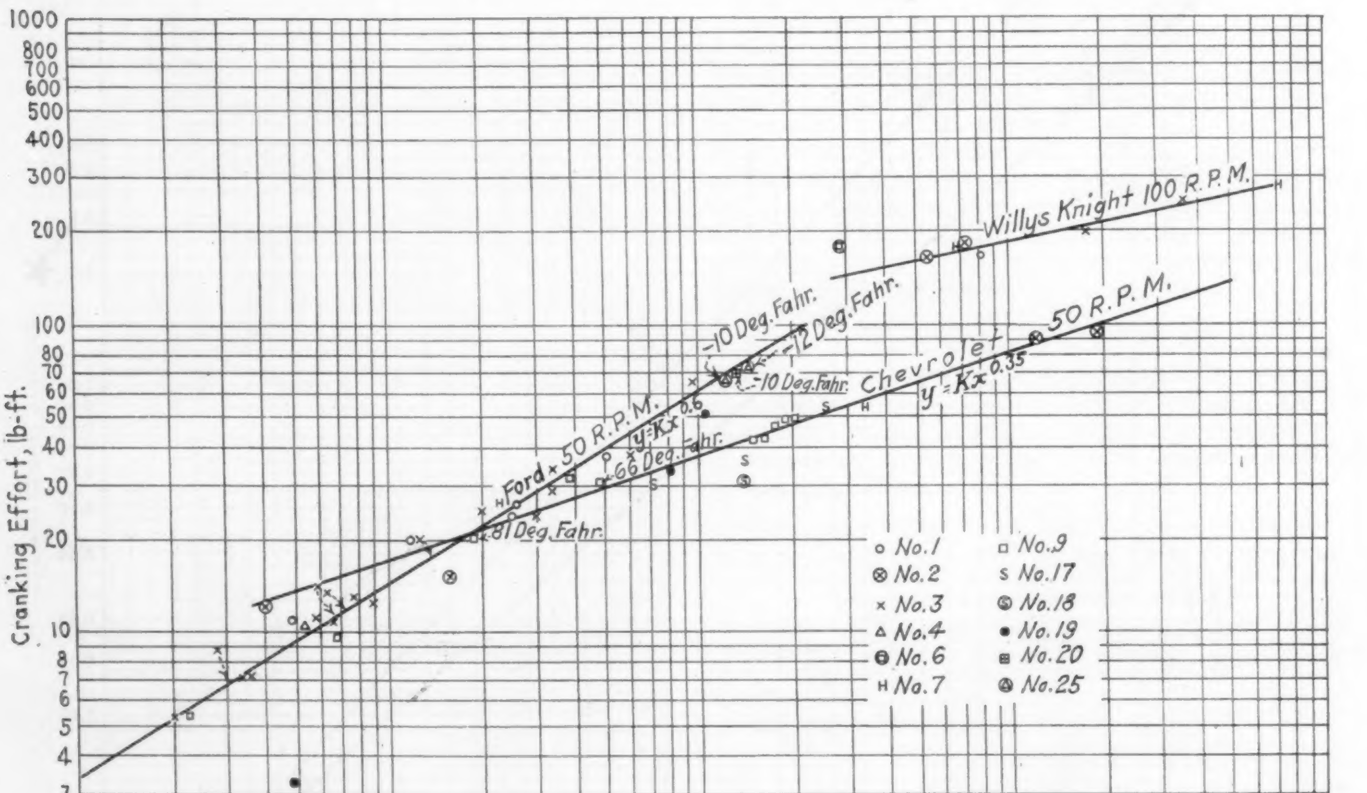


FIG. 9—EFFECT OF OIL VISCOSITY ON THE CRANKING EFFORT REQUIRED FOR THREE TYPICAL ENGINES

This Logarithmic Plot Shows the Cranking Efforts as Observed When Plotted against the Apparent Oil-Viscosity at High Shear-Rates as Estimated from Inspection Data by Means of the Herschel Chart. In Many Cases the Results Were Verified by Actual Measurements

tion to service conditions, the following engine-cranking tests were made.

Relation between Viscosity and Cranking Effort

To determine the effect of oil viscosity on cranking effort, several engines were subjected to cranking tests in the "cold room." These tests were made in the following manner: The engine under test was placed in the cold room and connected to an electric cradle-dynamometer through a gearbox which made it possible to operate the dynamometer at about three times engine-speed to secure smoothness. The gearbox was mounted outside the cold room and the resistance of the entire cranking train was small in comparison with that of the engine. When testing the Ford Model-T power-plant it was necessary to crank from the front end of the engine to reproduce car conditions. The other en-

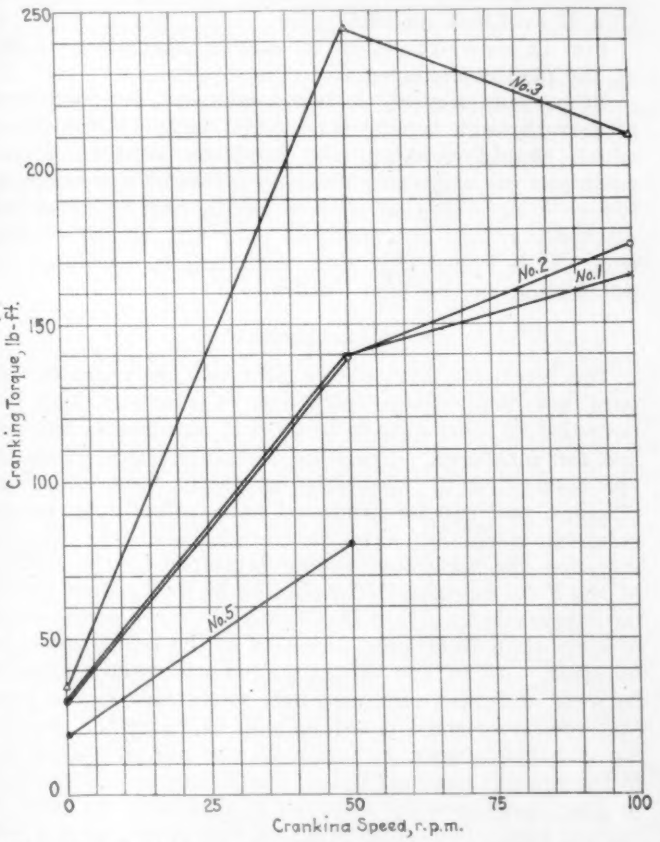


Fig. 10—Variation in Cranking Effort with Cranking Speed

The Drop in the Uppermost Curve at 100 R.P.M. Is Due to Frictional Heating Effects. The Chart Illustrates the Variation of Torque Required with Changes in Cranking Speed for a Specific Case

gines were coupled at the flywheel ends in the conventional way. All tests were made by running the engine first under its own power until thoroughly warmed up, and then draining, flushing and filling with the oil to be examined. The engine was then motored for 5 to 10 min. by the dynamometer, after which it was allowed to stand over night before making observations of cranking effort. Tests were made at the lowest temperature first, and the engine was allowed to stand from 15 to 30 min. after each observation to equalize temperature changes due to frictional heat. Thermometers were installed in the oil sump and in the water connections and tests were made only when all temperatures were substantially the same. Observations were made

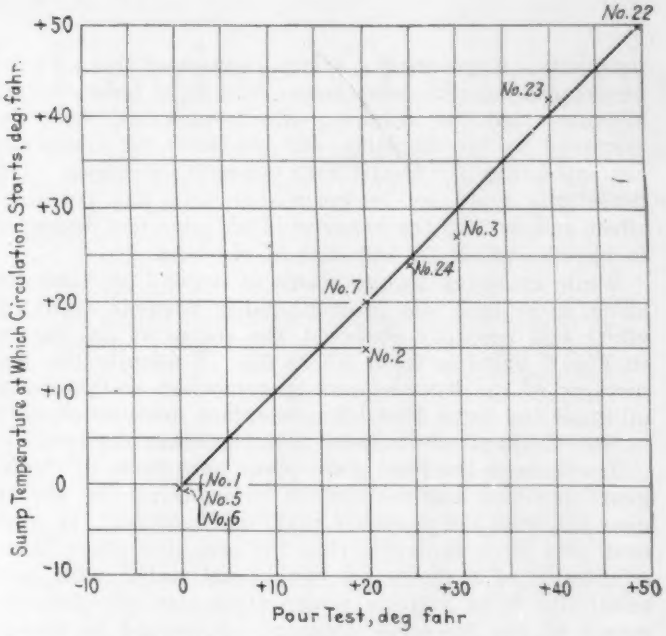


Fig. 11—Relation Between Pour-Point and Sump Temperature

The Sump Temperature Is That Required for Free Circulation in an Engine Provided with a 32-Mesh Screen Over the Pump Intake. The Tests Were Made in the Cold Room with a Four-Cylinder Sleeve-Valve Passenger-Car Engine

of the breakaway torque and the torque required to crank the engine at 35, 50, 70 and 100 r.p.m. No attempt was made to reproduce temperatures exactly. Instead, observations were made at temperatures ranging from +160 deg. fahr. to —10 deg. fahr., using oils varying in viscosity from 200 sec. at 210 deg. fahr. to 100 sec. at 100 deg. fahr., and pour-tests varying from +45 to —5 deg. fahr. In most of the work reported the spark-plugs were removed to eliminate pumping losses.

The results of these tests are given in Fig. 9, in which the cranking efforts as observed have been plotted against the apparent oil-viscosity at high shear-rates as estimated from inspection data by means of the Herschel chart and in many cases verified by actual meas-

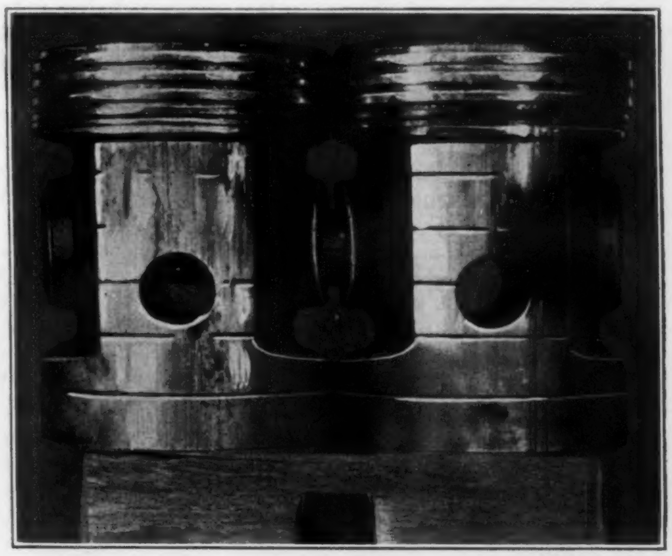


Fig. 12—Scuffed Aluminum-Alloy Pistons Resulting from Starting Under Conditions Which Prevented Free Oil-Circulation

urements. Experimental errors in work of this sort are necessarily large; nevertheless, the data indicate consistently that the cranking efforts observed were determined by oil viscosity, and evidently by viscosities corresponding to fairly high shearing-stresses. The deviations could not be correlated with any pour-test effect and, within the range studied, pour-test appeared to have no effect on the ease of starting.

While cranking torque seems to depend on viscosity alone, in no case was proportionality between cranking effort and viscosity observed, the slopes of the curves in Fig. 9 varying from 0.3 to 0.6. Evidently the immersion of the flywheel and transmission in the motor oil made the Ford Model-T powerplant more susceptible to the effects of oil viscosity than the other engines.

The tests on the Ford powerplant were made in "high-gear" position and correspond to cranking the car in gear but with the propeller-shaft disconnected. In general, this work indicates that the cranking-effort characteristics of a motor oil can be estimated with fair reliability from suitable temperature-viscosity data by means of the Herschel diagram. It should be recognized, however, that excessive pour-test effects may modify this conclusion to some extent. Furthermore, viscosities should be determined carefully at three temperatures as far apart as possible before attempting to extrapolate to low temperatures, as a comparatively unimportant error at normal temperatures becomes very large when extended to 0 deg. fahr. The slope diagram in the upper right-hand corner of the chart in Fig. 8 can be used for approximate comparisons of a general nature but is not where great accuracy is desired.

Variation of torque required with cranking-speed changes is shown for a specific case in Fig. 10.

Oil-Circulation Tests

In addition to its cranking characteristics, it is important that a motor oil circulate freely in the lubricating system even at very low temperatures. The tests recorded in Fig. 11 were made in the cold room with a four-cylinder sleeve-valve passenger-car engine. In these tests the engine was cranked by the dynamometer and allowed to run at 800 r.p.m. under its own power, the time and the sump temperature being noted with relation to the development of circulation as indicated by the oil-pressure gage. The thermometer in the sump was placed as closely as possible to the pump inlet, and the gage line was cleaned carefully before starting each test. The screen over the pump intake was of 32 mesh and had a total area of 28 sq. in. The oils examined included a wide range of viscosities and varying cold-tests as indicated in Table 4.

TABLE 4—SUMMARY OF OIL-CIRCULATION TESTS ON OILS HAVING A WIDE RANGE OF VISCOSITIES AND VARYING COLD-TESTS

Oil No.[13]	Viscosity in Saybolt Sec., at Deg. Fahr. 100	210	Specific Gravity, Deg. Baumé	A. S. T. M. Pour-Point, Deg. Fahr.
1	216	45	22.7	— 3
2	331	50	22.9	+23
3	565	61.5	23.8	+40
4	109	41	25.5	— 7
5	185	46.5	24.4	— 5
6	205	46.5	24.2	—10
9	...	161	22.6	+40
17	...	165	...	+80
18	...	165	...	+90
19	330	57	...	— 5
20	105	...	26	—10
25	106	...	25.9	—10

[13] The numbers of the oils are consistent throughout the paper.

It is obvious from Fig. 11 that pour-test was the factor determining the establishment of circulation, at least with this type of oil screen. In no case did the pressure gage show a consistent reading until the sump thermometer reached approximately the pour-point of the oil. In a few instances the gage would show some pressure at the outset due to the presence of oil in the pump. This pressure, however, would disappear in a moment and no further indication would appear until flow to the pump occurred.

Under the conditions of these tests, the establishment of circulation was wholly dependent on pour-test and was virtually unaffected by viscosity characteristics at higher shear-stresses. However, the *rate* of circulation after flow had started was undoubtedly influenced by such viscosity characteristics. As yet, no information is available on this point.

Fig. 12 shows the effect of lack of lubrication on two of the pistons removed from the engine.

At present, a study is being made of the conditions of flow through typical screen and pump-inlet systems which should establish the relations between screen mesh and viscosity and shearing stress at low temperatures. It appears that screens having coarser mesh will markedly reduce the effect of pour-test on oil circulation. It is hoped that this work will be available for publication in the near future.

Conclusions

The foregoing work shows definitely the necessity for both low temperature-coefficient of viscosity and low pour-test in lubricants to be used in automotive work at low temperatures. Cranking characteristics evidently are dominated by viscosities at fairly high shearing-stresses, and can be predicted satisfactorily by extrapolating inspection data on Herschel's chart. If, for instance, the maximum torque developed by the starter of the Ford engine at 50 r.p.m. be 80 lb-ft., then it will be impossible to attain this cranking speed with an oil of more than 16,500-sec. viscosity at the temperature in question. All of the values quoted will vary markedly between different engines; but, nevertheless, the general characteristics noted should be correct. At the lower temperatures, virtually all the oils examined up to the present have exhibited plastic characteristics and in most cases have not followed at all closely the laws of viscous flow. Those oils in which this deviation is great appear at a disadvantage for automobile-engine work due to their relatively poor circulation-characteristics, this effect being so pronounced under some conditions as to offset otherwise satisfactory temperature-viscosity susceptibilities. The conditions of shearing stress are much less severe at the intake to the circulating system than on the cylinder-walls, and free circulation requires, therefore, satisfactory viscosity under both high and low shearing-stresses.

Unfortunately, the types of crude which yield oils with a low temperature-coefficient generally tend to give rather high pour-tests and, conversely, those oils which naturally have low pour-tests also have very large viscosity-temperature coefficients. Since a low temperature-coefficient of viscosity is of the more fundamental importance, at both low and high temperatures, it appears logical to emphasize this characteristic and to eliminate or minimize the effects of pour-test by enlarging pump inlets, which would also help to eliminate clogging by ice crystals. An oil with both characteristics is the ideal for low-temperature operation.

Wright Whirlwind Engine Operation

Discussion of C. H. Biddlecombe's Aeronautic Meeting Paper[1]

EXPERIENCE obtained with the Wright Whirlwind engine in the 13 months of flying operation from June 18, 1926, to July 31, 1927, over the Boston-and-New York City Air Mail route is described. This period represents a total aircraft-flying time of 2146 hr. 35 min., or about 193,000 air-miles. Of the total flying-time, a three-engined Fokker airplane was used for 293 hr. 25 min., and during the remainder single-engined craft were used. The total engine-hours, therefore. was 2733 hr. 25 min.

Following a brief description of the three types of airplane used; namely, the Curtiss Lark, the Fokker Universal and Fokker Trimotor, all fitted with the Wright J-4B engine; this engine is described.

Special emphasis is placed on the cylinder construction, which is the outstanding feature of the engine, as the commercial success of the engine is said to be largely due to the remarkably efficient cooling obtained with this design of cylinder.

The inspection and maintenance system devised by the author is then taken up in detail, with an explanation of two of the forms in use: an "engine log-book sheet" and an "inspection card." The overhauling work required on the engine subsequent to a long period of running time is listed in detail; and a few cases of engine failure are fully described. Two tables, one showing the "Hours between Overhaul" of a group of 17 engines, the second giving data regarding 7 other engines, are appended. Parts of these tables consist of extracts from the records of two other Air Mail contractors and are reproduced through the courtesy of the Wright Aeronautical Corporation.

A brief comparison is made of the air-cooled and the water-cooled types of engine in commercial service, based upon the author's experience with both types, and comment is made on the advantages and disadvantages of three-engined aircraft for purely commercial operation.

CHAIRMAN HENRY M. CRANE[2]:—It is an interesting fact that, before the Wright Company adopted air-cooling, the same cylinder construction was used in the Hispano Type-E engine, within the limitations of the valve arrangement. With that construction, it was possible to run the engine continuously at 275 hp. for 5 hr. using doped fuel, whereas the Hispano engines imported into this Country in 1915 and 1916 had difficulty in passing a 4-hr. test at 150 hp. I take off my hat to the men who stood behind the work on air-cooled engines when it seemed hopeless, among them Commander Leighton, who was one of the first enthusiastic supporters of the belief that the Navy could eventually use air-cooling exclusively, as I believe it now does, nearly.

I was much interested in Mr. Biddlecombe's statements regarding fuel and oil, as I have been for 5 years one of the representatives of the Society on the Cooperative Fuel-Research Steering Committee of the Society, the American Petroleum Institute and the National Automobile Chamber of Commerce. This committee considers fuel characteristics and oversees fuel tests at the Bureau of Standards. Mr. Biddlecombe's fuel specification omits any reference to detonation. There are natural domestic gasolines that would comply with his specification and still vary in detonation characteristics enough to make a very wide difference in the compression ratios with which they could be used without being treated with ethyl fluid or benzol. Some of the California gasoline is best in that respect.

For 2 years we have been working, with the Bureau of Standards and with various people who are interested in anti-detonating compounds, upon a standard commercial specification in regard to detonation characteristics of fuel, but we have not arrived at it yet. In some ways the detonation characteristics of a fuel are more important than its volatility. When detonation begins, heat rises rapidly in the cylinder, resulting in blown-in pistons, bent valve stems, burned-out spark-plugs and other ills.

In the early Air-Mail operation, some twin-engine practice-airplanes were used and it was almost impossible to operate them in cold weather because one engine would become too cold while the other was being started. It was hard even to keep an engine idling without its getting too cold.

An obvious reason for using multiple engines is to increase the number of cylinders. If 25 is the maximum horsepower of an air-cooled cylinder, nine cylinders are not enough for a large airplane; 27 may be needed. I believe, however, that the air-cooled-engine design has reached a point where engines probably can develop 40 or 50 hp. per cylinder if this is demanded commercially. As a motor-car designer, I know that the possibilities of failure increase tremendously with increased complications. The difficulty of getting thorough inspection is very great, and failure from the same cause may occur in more than one engine simultaneously.

COMMERCIAL AVIATION TURNING TO LARGER ENGINES

F. B. RENTSCHLER[3]:—The thing of principal interest to our organization now is the beginning of the commercial application of our engines. So far we have not the wealth of experience of some of the other manufacturers, but we are satisfied with the comparative results of the 400-hp. air-cooled radial engine. Most of our substitutions have been for water-cooled engines, and they have shown the same comparative improvement as was experienced with the 200-hp. air-cooled engine. The Boeing Air Transport Co. has been operating since July 1. Its equipment consists of Boeing mail planes equipped

[1] This paper will be found in THE JOURNAL for November, 1927, p. 478, and the abstract is reprinted herewith. The author was formerly operations manager of the Colonial Air Transport, Inc., and is now a consulting aeronautical engineer in New York City.

[2] M.S.A.E.—Technical assistant to the president, General Motors Corporation, New York City.

[3] President, Pratt & Whitney Aircraft Co., Hartford, Conn.

with Wasp engines. After teething troubles such as were to be expected, largely due to installation, the operation of the engine has been quite successful. For Naval aviation the 400-hp. air-cooled radial engine has already proved itself very well, and the 200-hp. radial has proved itself for commercial use. Just how successful the 400-hp. engine and still larger sizes will be remains to be seen, but indications now are that almost the entire commercial industry is moving in the direction of large air-cooled radial engines.

At present we are guided in our engineering and experimental work by the requirements of the Navy, which probably will not need displacements much larger than 1700 or 1800 cu. in. For larger airplanes the question of multiple installation must be considered. The Navy, due to its special requirements, probably will not want larger engines, but for certain military as well as commercial purposes there is not the same limitation. I think that single-row radial engines up to 2000-cu. in displacement are entirely feasible. It is difficult to say what the power limitation will be for an engine of this displacement because of the growing use of superchargers, but it surely will be considerably more than 500 hp. The British Mercury engine, a development of the Jupiter, produces 800 to 900 hp., giving some indication of what can be attained with an engine of this description with supercharging.

Should Design for Easy Maintenance

R. W. A. Brewer[4]:—If you make a maintenance job easy, it is more probable that it will be done; if you make it simple, it is more probable that it will be done properly. An airplane engine requires running maintenance and overhaul maintenance, just as an automobile requires what we call running repairs and complete overhauling.

Running adjustments and repairs should be easily made with the fewest possible tools; for example, a pair of pliers and a screwdriver. It should be impossible or very remotely possible that any part be lost or dropped on the ground. We must remember that much of this adjusting is not done in the shop but in the open, often with the wind blowing and with dust all around or with snow on the ground. Any adjustment should be possible without the spilling of oil, because spilled oil accumulates dust, and if a mechanic puts his hand in oily dust and gets that on the bearing surfaces, serious damage may result.

Another consideration is the security of the adjustment when made. It is of no use to make an adjustment if it is not secure. Interchangeability of the small parts is desirable so that only a few parts need be carried in stock. Also it is important that, if some small part should break, the flier should be able to get from an ordinary source of supply a piece of material with which he could make a temporary repair.

The first important point about overhauling is to have some means of hooking onto the engine to lift it out of the airplane. Many engines have no provision for lifting except by putting ropes around the vital parts. Next, it must be possible to take the engine apart in a very short time, with the minimum number of screws, nuts, pins and the like to be removed, because every detail of the sort that has to be undone takes some time and may become lost, and if it does not conform to a commercial standard it cannot be replaced as easily as would be the case if it did.

Ease of handling is very important. A man should be able to handle any part with one hand. Complete subassemblies should be carried in stock, wrapped and ready for installing. All similar parts should be alike; avoiding rights and lefts simplifies the stock and reduces the chance of error. There should be, of course, as few bearings and other parts as possible, and bearings should be alike, or else so different that a man cannot put a bearing in the wrong place. It is easy to make mistakes otherwise.

I believe it is desirable that each part of an assembly shall hold in place the part that went on before, without using wrenches and other tools excepting on the final piece. As the last axiom I would say that it is undesirable to hold a mechanic to very close limits of adjustment. Designs requiring adjustment within 0.001 or 0.002 in. for proper functioning are undesirable.

Recently I have made for Pitcairn Aviation a design that aims particularly at a reduction of the manufacturing operations, and these to be such as can be done on ordinary machine-tools without elaborate jigs and fixtures. The engine is made from interchangeable parts and has either nine or seven cylinders. In this design we have followed, so far as possible, the maxims I have just stated. For instance, the clearance of the valve-operating mechanism can be adjusted without tools and without removing any part, by means of a graduated nut projecting beyond the rocker box. This can be done while the engine is running, without spilling oil.

Engine Life Greatly Increased

Archibald Black[5]:—Captain Biddlecombe's paper is most interesting to me, particularly his operating-cost estimates, on account of the extensive work I have been called upon to do along these lines. As one outstanding point I note that he allows for operation of three-engine airplanes 183,540 miles per year at 95 m.p.h. and for single-engine airplanes 173,880 miles per year at 90 m.p.h. These assumed mileages are considerably beyond existing practice. This feature interests me greatly, as reduction of transportation operating cost depends largely upon the intensity of operations. This is equally true in railroad, motorcoach and airplane operation. In a certain set of estimates recently compiled, I also allowed for intensive use of the equipment and I anticipate criticism on this point, although the figures used were not so high as Captain Biddlecombe's.

As regards the bases for calculating depreciation of airplanes and engines, Captain Biddlecombe's figures seem very conservative and could safely be increased. We are finding that post-war engines have a much greater life than we expected. I found it necessary to constantly increase the assumed life and only recently increased this estimate for the Whirlwind engine from 1000 to 1250 hr. A further increase may seem justified in the near future. At the end of this assumed life, I allow for a salvage value in usable parts as 25 per cent of the original value of the complete engine. This basis is better than I dare use for any other engine at present, although some of our larger American air-cooled engines are now proving themselves very satisfactory. The life of wartime engines was only a fraction of the life of our newer models.

One more comment on this matter of costs: Captain

[4] M.S.A.E.—Consulting engineer, Jenkintown, Pa.

[5] M.S.A.E.—Consulting air-transport engineer, Garden City, N. Y.

Biddlecombe has calculated his overhead costs separately, and I hope all who consider his figures will remember to include these overhead charges.

Failures Due to Lubrication Trouble

I. I. Chairman[6]:—My theory about the failures of the ocean fliers, which differs from Mr. Biddlecombe's, is that they were due to lubrication troubles. At least it is known that Miss Ruth Elder and George Haldeman had trouble on account of a broken oil-supply pipe on the American Girl, and the airplane was burned as soon as they were rescued, showing that the engine had lubrication failure.

Now I am an American citizen, but I was commander of the Third Flying Squadron, fighting against the Allies, during the war. During February and March, 1915, we were obliged to fly in all kinds of weather, sometimes at 30 deg. below zero, to keep in touch with the fortress of Prezemysl and over the Russian army, and our main source of trouble was lubrication. There were many cases of fliers who were burned to death, and examination of their airplanes showed that failure of lubrication caused the disasters.

Chairman Crane:—That overheating can result in a fire is shown by an experience of mine with a launch engine. After running about 30 miles at higher speed than it should have operated, the engine became noisy but was still running. I stopped it, opened the ports that were provided in the side of the crankcase and could see the crankshaft at a dull cherry red in the dim light of the crankcase. Its temperature was probably about 800 deg. An attempt to cool the shaft with cylinder oil started a fire in the crankcase.

Special Fuel and Oil Not Needed

J. H. Geisse[7]:—I take exception to Mr. Biddlecombe's statement that the air-cooled engine requires both a special fuel and a special oil. We have operated air-cooled engines on exactly the same fuel and oil as we use for water-cooled engines. An air-cooled engine probably is more susceptible to damage from using a poor fuel than is a water-cooled engine, but the requirements of the two are determined by the compression ratio more than by anything else. A water-cooled engine may operate for some time in spite of detonation, although the cylinders are burning all the time and examination will show them to be badly pitted, whereas air-cooled cylinders may be burned through under the same conditions.

Also, we have operated the latest J-5 type of Wright Whirlwind engines in the laboratory at normal summer temperatures, with the altitude control adjusted for a lean mixture to give the best economy, and have had no trouble. That was not true with the J-3 and the J-4.

T. Z. Fagan[8]:—In Mr. Biddlecombe's paper it was stated that trouble was experienced occasionally due to moisture collecting at the distributor segments after a heavy rainfall and causing irregular firing of one or both sets of spark-plugs. This trouble was said to be cured by the application of vaseline or by using a wax seal, or even chewing-gum in emergency, on the high-tension-lead outlets.

Shielding the magneto with a light metal hood of suitable design prevents this difficulty. It is of the utmost importance to shield the Scintilla aircraft magnetos on the Whirlwind engine. The Scintilla company does not approve makeshifts such as Mr. Biddlecombe mentioned. The holes in the distributor blocks for the spark-plug cables are not the seat of this difficulty, as it is almost impossible that water can form an electrical connection between the terminal at the bottom of these holes and other like terminals or parts of the magneto. It is, however, likely that water can leak through the joints between the distributor blocks and the main cover and front end-plate, where ease of dismantling is of importance. These joints, though protected with felt strips, cannot be relied upon always to resist the entrance of water, particularly when the airplane is in flight with the rain coming against the magnetos with considerable force.

Breakage of breaker-lever springs could have been prevented by the use of proper cowling for the magneto, as that prevents moisture from entering the joint in the breaker-housing cover and causing the breaker-lever springs to rust.

I take this occasion to emphasize Mr. Biddlecombe's statement regarding the shielding of the magnetos and to urge that all magnetos be protected adequately from direct exposure to rain and the other elements. This recommendation is quite as reasonable as to urge that the generating mechanism of all power stations be adequately housed, instead of being mounted for operation in the open.

[6] New York Edison Co., New York City.

[7] M.S.A.E.—Chief engineer, aeronautical engine laboratory, Naval Aircraft Factory, Philadelphia.

[8] M.S.A.E.—Vice-president, Scintilla Magneto Co., Inc., Sidney, N. Y.

Motorcoach Engine Design

It is commonly known that the strain which has to be borne by the engine of the modern motorcoach is greater than that called for in the case of the passenger-car engine. This subject has been most lucidly dealt with by L. H. Pomeroy, chief engineer of the Associated Daimler Co. A single-deck motorcoach, he says, will give about 50 ton-miles per gal. in service, compared with the passenger-car engine's 35 ton-miles, a ratio of 1.43 to 1. Further, as the quantity of gasoline used by a single-deck coach is about 6000 gal. per year for 50,000 miles, against the passenger-car's 700 gal. per year for 12,000 miles, the actual work done by the motorcoach engine is approximately six times that of the car engine. Now, to quote Mr. Pomeroy, the rate at which this work is done, that is, the horsepower, depends upon the time, or the running speed. If this be assumed to average 18 m.p.h. for the motorcoach and 30 m.p.h. for the car, the yearly running time for the motorcoach becomes 2780 hr. and for the car 400 hr. The gasoline used by the motorcoach is then 2.16 gal. per hr. and by the car 1.75 gal. Thus, as the motorcoach engine has been shown to be working with 43 per cent higher efficiency, the actual power developed will be 1.75 times that developed by the car engine. In these circumstances it is apparent that the motorcoach engine must be designed to work no less than 75 per cent harder than the equivalent passenger-car engine and, at the same time, must be capable of sustaining that rate of work for nearly seven times the number of running hours per year.—*Modern Transport* (London).

Rise and Fall of Firms in Automobile Industry

THE automobile industry, although stabilized in the sense of being firmly established and enjoying a steady demand for its product, is still young. Between 1903 and 1924, inclusive, a total of 180 companies engaged in the manufacture of automobiles. Undoubtedly, there were during these years a number of other companies, some of which probably engaged in fabricating automobiles. Most of them, however, were business units, either incorporated or otherwise, which simply existed in the minds of the men who organized them. Any estimate which included these "paper" firms would run high indeed. To count them might throw light upon the number of aspirants to automobile manufacture; but it would hardly afford a picture of the rise and fall of actual manufacturing establishments.

Of the 180 companies which, in this strict sense, engaged in passenger-car manufacturing over this 22-year period, more than two-thirds have retired from the field. Less than a dozen have been in the business for the entire period. The average length of life for all 180 companies, has been 8 years. Only five companies have remained in business for 25 to 27 years, and only two have survived a 28 to 30-year period.

Mortality in Automobile Manufacture

In the absence of satisfactory comparable data for other separate industries, it seems evident that the mortality in automobile manufacture is high; only 33 per cent of the firms which actually got started at any time during this 22-year period survived. One would expect the hazards to be greater in a new industry, especially one making a complex fabricated product, subject to constant change and improvement in design and construction. This recurrent necessity of making innovations in both the character of the product and in methods of manufacture, if a firm's place in the industry is to be maintained, probably serves to explain in large measure the complete disappearance of many automotive names that were once highly respected. Coupled with this imperative necessity of making alterations in the character of the product has always existed the danger of making them too readily or too drastically. For, if insufficient change of practice means stagnation, so also do frequent and complete shifts of production policy spell manufacturing and marketing confusion. The high general level of failures in automobile manufacture remains in large measure due to the great difficulties present in striking a proper balance between sales and manufacturing policies. The extraordinary exit-figure in 1910, of 25 per cent of all firms engaged in the field, is probably due, above all, to the absolute falling off in the demand for high-priced cars which occurred in that year.

Increased Ease of Manufacture

Following the year 1912, the percentage of failures fell almost steadily. It had been 12 per cent in 1912; it became 9 per cent in 1916, 6 per cent in 1920, 1 per cent in 1921. How explain a decline as great as had been the general ascent during the period from 1907 to 1912? In the first place, there was an increased ease of manufacturing. Not only were fundamental changes in design less frequent after 1912, but the general growth of the industry had made the purchase and employment of good materials and standard parts a fairly simple matter. The establishment of the Mechanical Branch of the Association of Licensed Automobile Manufacturers, in 1906, had marked the beginning of a general program of cooperative technical research. The movement toward the standardization of materials and parts, initiated by Howard E. Coffin, Henry Souther and Coker F. Clarkson, received a fresh impetus in 1910, when the Standards Committee of the Society of Automotive Engineers was formed. "The apparently easy path (of standardization) was strewn with pitfalls, which it took years of study and continuous effort to learn to overcome." Eventually, however, order was brought out of what formerly had been chaos.

The survival of many firms, especially the small ones, was great. Not only did the purchase of standardized parts and materials become much easier between 1913 and 1921, but their relative costs became much lower. Production on a steadily growing scale resulted in both external and internal economies; lower costs enabled manufacturers to sell their products at lower relative prices, and each lowering of price increased the quantity sold. The number of entrances into the industry could greatly exceed the number of exits, between 1913 and 1921, and the proportion of failures could be comparatively low, because most companies during this period engaged in the production of inexpensive cars and the market for low-priced cars kept on expanding at a remarkable rate.

Period of Rising General Prices

A further cause of the falling proportion of failures between 1913 and 1921 probably lies in the fact that this period was one of rapidly rising general prices. Except for the year 1914 and a part of 1915, the Country enjoyed general "prosperity"; money conditions were easy, full employment prevailed, large numbers of the working class received higher money wages than ever before. In accordance with the common difficulty of distinguishing real purchasing power from money income, many workers spent their wages more freely than ever; and the purchase of automobiles was a popular form of expenditure. Ability to purchase was also doubtless made easier by the new institution of installment sales which developed during these years.

But with the crisis of 1920, and the depression of 1921 and 1922, came a sharp reversal of general business conditions. Twenty-two firms withdrew in 1922 and 1923. Fourteen more exits were made in 1924. The proportion of failures rose steadily from 1 per cent in 1921 to 19 per cent in 1924.

The failure figures of 10 per cent in 1922 and 14 per cent in 1923 are due largely to the influence of general business conditions, rather than to any characteristics of the automobile industry itself.

Test of Survival

Of the 10 original leaders in 1903, only one remains a leader in production. Of the 10 leading firms in 1924, only 2 had been in the industry less than 10 years. Most of the present leaders are not, strictly speaking, pioneers; they date back less than 20 years. But the successful units organized since 1908 have all been piloted by pioneer manufacturers. Most of the 1903 leaders who in later years either fell below tenth place, or else went out of business entirely, failed to sense certain changes which shortly took place in market demand. Their failure to sense market currents, rather than any lack of technical or manufacturing ability, accounts for their displacement as leaders. To make cars at low cost is one thing; to make cars that consumers want is another.—Ralph C. Epstein in *Harvard Business Review*.

Symposium on Tire-Size Simplification

HEREWITH is printed part of the paper on Tire-Production Progress and Size Simplification, by B. J. Lemon, together with written and oral discussion on the simplification of tire sizes, by H. M. Crane and R. M. Hudson, as presented at the Nov. 21, 1927, meeting of the Detroit Section. The first part of Mr. Lemon's paper, which is an instructive resumé of the more recent developments in the growing of rubber trees, obtaining the latex from them, and utilizing the rubber in the production of cord tires, is reserved for later publication.

The appeal made by Mr. Lemon in the latter part of his paper for simplification of tire sizes was particularly opportune. Describing the waste of man-power caused by the production and distribution of a multiplicity of sizes of tires that entail unnecessary expense and finally sleep in factory storehouses or in branch warehouses, the author makes an appeal for a reduction in the number of standard sizes of automobile tires. He cites the curtailment of sizes during the war when crude rubber was scarce, gives the reasons for the increase in number since that time and its effect on the cost of tires, and states the attitude of the tire manufacturer toward the program of simplification.

Mr. Crane discusses the subject of tire-size simplification from the point of view of the motor-car manufacturer, with particular reference to the passenger-car field. He calls attention to the stress laid on the sales value of the appearance of cars and the consequent reduction of wheel sizes, refers to the recommended practice for rims for low-pressure tires adopted by the Society in 1926, and states his belief that the limit in the reduction of wheel diameters has nearly been reached. He thinks that many of the sizes are due to improvements in construction, but asserts that many of the special sizes are used only on cars of limited production-volume. The average car owner seems to give tire equipment no consideration, except possibly to ask for some favorite make of tire. Conditions appearing in the motor-car and tire industries indicate that the time is ripe for simplification and standardization, because many sizes are unnecessary.

Mr. Hudson declares that the need of simplification is evident. Sales departments, however, lose interest in a development as soon as it reaches a standard state. Tire dealers and manufacturers, car manufacturers and motorists are aware of the unnecessary burdens being carried but are swayed by the sales departments, which desire new talking points. The only way to get under a manufacturer's skin, states the author, is to touch his pocketbook. Statistics revealing that neither the automobile nor the tire industry is in the front rank of profit-making industries are given. Future car sales will be mainly for replacement, Mr. Hudson believes; competition in foreign markets will be stiffer henceforth and competition at home will be with other industries rather than with other companies in the automotive industry. Close attention must therefore be paid to the elimination of waste through simplification and standardization. Allied industries should co-operate. He suggests a joint committee of the Society and the tire industry to work out a list of tentative tire sizes, and pledges the support of the Government in helping to put the program into effect.

Economic Waste of Needless Tire Variety

By B. J. LEMON[1]

THE great problem of production that confronted the tire manufacturer during and immediately after the war has now been overshadowed by a greater problem of economic balloon-tire size-simplification. More tires can be produced than can be used, despite the astonishing increase in the sale and use of automobiles and notwithstanding the large yearly additions to our already magnificent systems of public highways. All the new production methods that, by the greatest stretch of the imagination may be introduced, will not suffice unless scientific tire-simplification and distribution can be effected. The cost of marketing balloon tires is a disgrace to American business intelligence.

Today a multitude of balloon-tire sizes, differing in cross-sectional diameter by as little as 1/4 in., must be kept in stock by manufacturers and retailers, causing an enormous amount of capital to be needlessly locked up and preventing that economy of production which can be realized only by making fewer sizes in large quantities. This applies not only to tires but to wheels, rims, and rim holders.

[1] M.S.A.E.—Field engineer, tire development department, United States Rubber Co., Detroit Plant, Detroit.

The number of tires that sleep in factory storehouses or in branch warehouses represents man-power that, for the time being, is doing nothing; man-power wasted because of the production and distribution of useless sizes. Balloon tires, in the large number of sizes now made, are a drug on the market, a millstone about the necks of both automobile and tire manufacturers, and automobile and tire dealers. The elimination of waste due to the increasing number of tires will not only increase profits to motor-car and tire manufacturers; it will lift a dead load from the tire dealers and result in quicker turnover and in a profit to the dealers, the majority of whom cannot begin to stock one-half the sizes required by current makes of automobile. How shall we seek to classify such a conglomeration of sizes? Simplification is the only hope. To simplify or not to simplify; that is the leading tire question.

INGENUITY RESULTING IN PROFITLESS ACTIVITY

During the war, when the supply of crude rubber was curtailed, tire sizes were reduced from more than 100 styles and sizes to 9 sizes. This meant lower inventories, smaller investments and greater economy.

Tire manufacturers and dealers alike were prosperous. Then came the balloon tire, with four original sizes. Lower cars, which meant lower wheels, were on the horizon. Tire diameters started downward, sizes multiplied, four and six-ply tires were introduced, until today, in the balloon-tire field alone, we are required to produce the astounding total of 40 or more sizes, scattered over 10 cross-sections and 4 different wheel-diameters. This condition, aggravated by increasing the grades of tires, results in some tire-makers being compelled to produce more than 300 styles to cover the present field.

With the adoption of each new tire-size comes a price struggle for the new business. A finished tire is the result of three elements: raw materials, labor, and ingenuity. Materials and labor can go only to a certain price-level without squeezing out the last penny of profit; in some tire sizes the present tire-situation has brought us dangerously near this price-level. The saving factor has been ingenuity in production. Ingenuity in manufacturing prevents dry rot in industry. Nothing so characterizes American business as continual rapid change. Certainly, the success of our whole industrial structure depends on pressure, which forces new ideas into open minds. But the ingenuity that is displayed in creating a new tire-size 1/10 in. above or below some other size is not the type of new idea that will produce possible profits in the tire industry. New tire-sizes are bullying the producer into selling his product at little or no profit, which from the standpoint of the law of supply and demand, will in the end be as ruinous to the buyer as to the seller. Multiple tire-sizes are tending rapidly toward profitless prosperity in the tire industry.

Five Sizes Comprise 80 Per Cent of Sales

Of the 40-odd cross-sectional sizes of balloon tire, close to 80 per cent of the sales to car manufacturers in 1927 were in 5 sizes. In other words, only 20 per cent of car production would be affected by eliminating 80 per cent of the balloon sizes now in current use.

Let us see who should be interested in this war on tire waste. Fifty car makers, 100 tire manufacturers, 55,000 car dealers, 125,000 tire dealers and 20,000,000 car owners. Canvass this army group by group. Each group favors simplification, for each knows that simplification touches his pocketbook.

The car maker and car dealer know and admit that fewer sizes would spell lower cost of original equipment, lower stocks and less confusion in the wheel, rim and tire departments of the factory branch. The car maker, or his engineer, is not responsible by any means for all the balloon-tire confusion. His decision to use a new size is more often influenced by cost, appearance, or a different size-marking than by actual performance. As a matter of fact, many new tire-sizes are suggested by the tire maker and adopted before extended performance-tests are possible. This decision, however, has a very far-reaching effect, because, after it has once been made, there is no escaping the production of this new tire until all the cars requiring it have finally reached the scrap-heap.

How Obsolescence Absorbs Profits

The tire manufacturer knows that expensive mold and other equipment, which often becomes obsolete, so far as his business is concerned, before sales begin to pay for it, is loading his inventories and cutting his profits to the narrowest of margins.

As an example, in January, 1927, we brought through 100 molds for a new size of tire for a popular make of medium-size car. This equipment cost about $30,000. During 5 months' production, 100,000 tires were delivered to the car manufacturer, after which another tire of smaller diameter was adopted, making this mold-equipment obsolete, for no car before or since has used this particular size. For this mold-equipment alone, each original-equipment tire cost 30 cents. Any tire-maker who figures his cost to a fraction of a penny knows that 30 cents per tire for mold-equipment is ruinous, when tires are sold to a car manufacturer at as close a figure as they are in the present market.

Uneconomic Competition in Tire Grades

Yet, in another sense, the tire manufacturer is jointly responsible for his own predicament. He allows himself to be pushed by uneconomic competition into making second, third, and even fourth-grade competitive tires for wholesale and retail markets; grades that will fit all the price levels of all classes of car owner. Increasing the number of grades is as serious as turning out new sizes for original equipment.

The tire dealer, bewildered by the multiplicity of tires, is unable to keep track of the field demands without a tire dictionary, to stock one-half the sizes in current use, or to turn over his investment at anything like a livable profit.

And, finally, the motorist who may own a vehicle requiring a new or passing tire size must shop from dealer to dealer in an emergency to find the equipment without which his car is useless.

Remedy Seen But Cooperation Lacking

Here we have nearly one-quarter of our total population, the brains and backbone of the greatest transportation industry the world has ever known, all apparently of one mind, yet as disorganized and uncoordinated as an army in retreat.

Who will be the Foch to coordinate the groups and lead the battle on tire waste? Secretary Hoover has the campaign thought out and mapped out. A simplified program has been tentatively adopted. The division heads of the Rubber Association of America, the Society of Automotive Engineers, and the National Automobile Chamber of Commerce have conferred. Will they as leaders vow allegiance to the cause and, by gentlemanly agreement or some other means, nail the flag of simplification to the citadel of the world's leading industry?

The time is ripe for the adoption of a simple range of balloon-tire sizes that will fulfill all the present requirements, allow for future development, and at the same time reduce stocks and the cost of motoring in a manner quite apart from the intrinsic value already passed on to the automobilist in the form of an improved balloon-tire.

Simplification of Tire Sizes

By H. M. Crane[2]

IN discussing the subject of the simplification of tire sizes as it appears to the motor-car manufacturer, I shall confine my remarks to the passenger-car field, as it has a considerably longer history than the other fields, and its history is complicated by a greater number of contributing considerations.

A notable step toward reducing the number of passenger-car tire-sizes was taken during the war. We were then using only so-called high-pressure tires, and the question of motor-car appearance had not become of such great sales importance as it is now.

About 5 years ago the so-called balloon-tire, or, as I prefer to call it, the low-pressure tire, was seriously proposed for passenger-car use. I have believed this proposal to be only a belated recognition of the futility of using pressures from 70 to 90 lb. per sq. in. in passenger-car tires after the perfecting of cord construction had made such pressures entirely unnecessary.

Due to a number of causes, the low-pressure tire was put into actual construction very rapidly, with many of the important engineering problems affecting it, and affected by it, entirely unsolved. In the first place, a natural reaction from high pressure produced an attempt to use considerably lower pressures than have since proved to be practical. Tire proportions and tire construction for these new low pressures could not be worked out in a short time, and it is certain that only recently such matters could be said to be under fairly good control by tire designers. The use of low-pressure tires also introduced some very serious problems into passenger-car design, for they affected steering and riding to an unexpected extent. Problems in connection with steering, such as the necessary ease in parking and the suppression of shimmy, have never been entirely solved and have required, therefore, a modification of tire pressures to allow satisfactory operation.

The low-pressure tire, as I have said, has also brought some entirely new problems into passenger-car riding. I have no hesitation in saying that the recent landslide toward the use of spring damping-devices has been due largely to causes originating in the low-pressure tire. This type of tire has a very considerable spring-action all its own, which must be entirely undamped, else excessive friction will result in rapid deterioration. Desirable inflation-pressures are, therefore, also affected by the final decision regarding springing and other similar features.

Low-Car Demand Affects Tire Size

I think I have given ample reasons for the fact that various attempts at simplifying the number of sizes of low-pressure tires have been complete failures to date. I believe, however, that we are now approaching a reasonable stabilization in tire pressures, which may be expected to allow standardization of tire construction in some degree. I assume, therefore, that the list of tire sections proposed by the Tire and Rim Association represents a recognition of this idea.

Unfortunately for the prospects of immediate simplification in tire sizes, the last few years have brought out very prominently the sales value of appearance in passenger-cars. The wheels and the necessary fenders play a very prominent part in motor-car appearance. The car-buying public has shown a marked preference for cars of low appearance; and the apparent height of any passenger-car is greatly affected by the size of the wheels and of the tires. As a result, a continuous reduction in wheel diameters has occurred during the last few years. The larger tire-sections required by low inflation-pressures have resulted in smaller wheel-centers, but the reduction in the size of wheel-centers has proceeded much farther than would have been necessary to meet this requirement. In the old list of high-pressure tires, the smallest wheel-diameter was 23 in. Today, a very large number of 18-in. wheels are in use; and, apparently, before long none will be larger than 20 in.

To Present Revised S.A.E. Recommended Practice

At the Summer Meeting at French Lick Springs in 1926, the Society adopted a recommended practice for rims for low-pressure tires. This table is shown on p. 437 of the S.A.E. Handbook. It was an attempt to standardize, if possible, the interchangeability of tires. At this date, about 18 months since its adoption, this table has become largely obsolete because of the change in wheel sizes just mentioned. The Tire and Rim Division of the Society has been watching conditions as closely as possible and, at the next Annual Meeting, expects to present a revised table for recommended practices based on the best information that can be obtained as to the probable conditions in 1928. Whether this table will mean any more in actual practice than the last one, it is now too early to state.

I believe that, for engineering reasons, and for appearance reasons, also, the desirable limit in the reduction of wheel diameters has very nearly been reached. We are already very cramped for space in applying the necessary braking-apparatus, at a time when the higher speeds make better brakes more important than ever. My personal opinion is that, so long as the 56-in. tread for cars is retained, wheel diameters will not be reduced much further for purposes of appearance. I think that an examination of some of the smaller cars having very small wheels, from either the front or the rear, will tend to confirm this view. I believe that the action of the Society in first attempting to standardize only rim fits is fully justified by the history of the last 2 years. Certainly, if we cannot succeed in this primary detail of simplification, there is no chance of expecting major simplification for some time to come.

Variety Due to Tire Improvements

Everyone must admit that the picture Mr. Lemon has drawn in his paper is fair as regards the difficulty experienced by any tire maker or tire dealer in meeting all possible calls for tire replacements. The carrying of many tire sizes that are infrequently called for undoubtedly represents a considerable economic loss. On the other hand, I am sure that many of the existing conditions are the result of the working of economic forces that must be taken into consideration. Mr. Lemon has described at considerable length in the first part of his paper the remarkable advance that has been made in

[2] M.S.A.E.—Technical assistant to the president, General Motors Corporation, New York City.

tire design and construction during the last few years. One result of this improvement has been to make possible the use of widely varying types of construction and of sizes to carry any particular load. We thus find tires having the same nominal size rated very differently as to load-carrying capacity, because of differences in their construction. The durability of tires, as represented by available mileage, can also be varied through a wide range. The result has been encouragement of the manufacture and sale of several different tires of the same nominal size to meet different requirements. Even in the old high-pressure-tire size of 5 x 33 in., several makers sell two types of construction. This unquestionably tends to complicate the situation for tire manufacturers and dealers, but, in the long run, is probably of economic advantage. Some years ago, it became customary to use the same rim-size on both the front and the rear wheels of passenger-cars, and for a time the tire equipment was also interchangeable. Today, it is not uncommon to use a four-ply front tire and a six-ply rear tire. I am inclined to think that, in view of the relative work done by the front and the rear tires, this is economically advantageous.

Conflicting Tire and Economic Pressure

A car manufacturer encounters another kind of economic pressure due to increasing the weight of a particular model. Standard tire-equipment is no longer capable of sufficiently satisfactory service. If the use of low pressure is to continue, as is ordinarily necessary because of riding considerations, larger cross-sections must be used. This can be accomplished either by enlarging the outside diameter of the tires and using the tires on rims of the same diameter as at present, or by maintaining constant the outside diameter of the tires and reducing the diameter of the rims. The latter change is frequently considerably cheaper for the car manufacturer, because the rim equipment can be changed more easily than the body and fender tools.

Again, it has become apparent that a distinct increase in the carrying capacity of a given tire shoe can be obtained by mounting it on a wider rim. In a large-production problem, economy of doing so as against using a larger tire will be obvious. In other words, a continuous and strong economic pressure on the car manufacturer has a considerable bearing on the equipment finally used.

It is futile to say that a saving made by the manufacturer, and therefore directly in first cost by the motor-car buyer, may not be wiped out in the field by greater cost of distribution. Possibly, conditions are not quite so bad in the field for the bulk of motor-car users as a hurried reading of Mr. Lemon's paper might suggest. For instance, the Ford and Chevrolet companies today use the same tire size, and have done so for several years. Between them they supply a majority of car owners. In the high-price group, the Lincoln, Packard and Cadillac companies have used interchangeable tire sizes, and I believe still do so, although all have changed to a smaller wheel-diameter. Many of the special tire sizes in production are mounted on cars of limited production volume. Such cars depend for their sale on being different from the large-production models. They are bought because they look different, not because they represent more value for the money.

Car-Buying Public Shows Little Interest

I have attempted to state briefly the various causes, as I see them, for the present large number of low-pressure-tire sizes. I hope and believe that we have almost reached the peak in this respect and that beginning with 1928, we shall begin to see an improvement. I should be much surer of this if the motor-car-buying public had shown any sign of taking an interest in this important question. As tires at present give so little trouble, and as their distribution is so well taken care of, the average car-owner, in making a purchase, seems to give tire equipment practically no consideration. He may ask for some favorite make of tire when buying a new car, and he will, of course, inspect the condition of the rubber on a second-hand car, but rarely, if ever, will he discuss the tire size.

On the other hand, I see conditions appearing in the motor-car and the tire industries which indicate that the time is ripe for improvement. In the first place, simplification or standardization is never successful except as the result of experience. It seems to me that sufficient experience in the use of low-pressure tires has now been accumulated to eliminate, at least theoretically, a large number of unnecessary sizes. Unfortunately, several years must elapse before any simplifications, no matter how successful, will begin to show results in the field. The sooner we begin, however, the sooner we can expect to reap some advantage.

The Society hopes to present at the Annual Meeting a proposed revision of rim standards, coupled with a recommendation of the Tire and Rim Association as to tire sections. We hope thus to have available a list of simplified sizes, but we cannot, of course, guarantee their use by any or all manufacturers. It is probable, however, that, being based on current practice, the sizes will represent the major part of tire production.

Simplification an Aid to Industrial Self-Preservation

By R. M. Hudson[3]

IF any one is in doubt of the need of tire simplification, he might look at the formidable array of sizes given in Table 1. I understand that this is only part of the total variety. When to it are added the truck tires, the motor-coach tires, and the tires that are used on the little tractors that run about the shops, the variety is very great. I can see why the works manager of a plant might come to this conclusion.

After 6 years of contact with industry on simplification programs, I find that the sales department loses interest in a project as soon as it reaches a relatively standard state; that the desire is for something new, for more variety of one kind or another. So, I shall not discuss the technical side of tire development, the problem of variety, or what a burden it is to everyone concerned with it.

Tire dealers and tire manufacturers are well aware of those burdens. Motorists are beginning to wake up to what a burden it is to them. Some car manufacturers may be aware of what a burden it is to them; but I

[3] M.S.A.E.—Assistant director, commercial standards, Bureau of Standards, Department of Commerce, City of Washington.

think they are either reluctant to admit it or are swayed by the sales department's interest in new styles and new features, which, of course, give the salesman something to talk about.

The points that I should like to make are these: That these are days when margins of profit in a great many different lines are becoming steadily smaller. Because of this fact, there is only one place where you can get under a manufacturer's skin; you must touch his pocketbook nerve, so to speak. In fact, you must make the nerve tingle, as a nerve in your tooth tingles when the dentist touches it with a drill, before some manufacturers will wake up to the seriousness of the situation. I am not saying this with particular reference to the automotive industry. I am generalizing with regard to industry as a whole, because we have had some contact with more than 300 different lines, and in them all the same mental attitude seems to prevail at the start. After a while, when manufacturers, distributors and consumers get together to discuss a common problem, they take more interest and a program is gradually developed.

Variety Responsible for High Overhead

We have some 80 programs in effect. I am glad to say that a recent survey shows that, in 22 of those lines, the average adherence is more than 80 per cent. In other words, in the lines to which I refer, 80 per cent of the production during the periods surveyed conforms to the standards, leaving an average of about 20 per cent to take care of the special or "off" sizes. Another thing that has become more or less axiomatic is that surveys of many different lines show that 80 per cent of the business usually comes from 20 per cent of the varieties offered, and that 80 per cent of variety brings in only 20 per cent of the total business. This is responsible for the high overhead, the high manufacturing cost, and the wastes that have been referred to.

To show some of the facts and figures indicating the general condition of American industry, I invite your attention to Table 2, taken from the last report of the Bureau of Internal Revenue and derived from income-tax returns. In 1925, out of 430,000-odd corporations

TABLE 2—PROFITS AND LOSSES IN AMERICAN INDUSTRY[4]

Year	1922	1923	1924	1925
Total Corporations Reporting, No.	382,833	398,993	417,421	430,072
Total Number Making Profit	212,535	233,339	236,389	252,334
Per Cent Making Profit	55.5	58.5	56.6	58.7
Gross Income, millions, (A)	$80,331	$97,457	$97,158	$113,692
Net Income, millions, (B)	$6,963	$8,321	$7,587	$9,584
Margin of Profit, $B/A=C$ Per Cent	8.6	8.5	7.8	8.4
Total Number Showing Loss	170,348	165,594	181,032	177,738
Per Cent Showing Loss	44.5	41.5	43.4	41.3
Gross Income, millions, (D)	$20,588	$21,106	$22,070	$22,499
Deficit, millions, (E)	$2,193	$2,013	$2,223	$1,963
Average Loss, $E/D=F$ Per Cent	10.6	9.5	10.0	8.7

[4] Data from Internal Revenue Bureau, Treasury Department.

reporting to the Bureau, 252,000 made a profit, while about 178,000 did not. The average percentage of firms making a profit during the last 4 or 5 years is about 58. The average of those which have not made a profit in that period is close to 43 per cent. Coincidental with that state of affairs, more than 157,000 commercial failures, totaling more than $5,000,000,000 occurred in the United States from 1923 to 1927. This year, 1927, to date, has a much higher failure-record than any other year of this period.

The Industry's Profit and Loss Standing

In analyzing the statistics of the profits and losses in American business, I have taken only 10 instances in each case. Table 3 shows the industries in which the percentage of profit-making companies is the highest. In these industries the percentage of profit-making companies reaches 60, 70, or, in one instance, even 80. Neither the automotive nor the tire industry is included in this list. If these statistics are analyzed a little differently and the lines are sought in which the profits of individual companies average the highest, as shown in Table 4, you will find that the motor-vehicle industry

TABLE 1—TIRE SIZES SUPPLIED IN 1927 TO AMERICAN AND BRITISH CAR BUILDERS

Wheel Diameter, In.	18	19	20	21	22	23
	Nominal Tire Sizes, In.					
British		26x3.50				
British		27x4.00				
British		27x4.40				
American			28x4.40			
				29x4.40		
British						
American				30x4.50		
American		28x4.75	29x4.75			
American						
			29x4.95			
British		28x4.95				
American		29x5.00	30x5.00			
American	28x5.25	29x5.25				
			30x5.25	31x5.25		
British					32x5.25	
American		29x5.50	30x5.50			
American			30x5.77			33x5.77
American	30x6.00	31x6.00	32x6.00			
				33x6.00		
British						
American	30x6.20	31x6.20	32x6.20	33x6.20		
American	30x6.75	31x6.75	32x6.75			
				33x6.75		35x6.75
British						
British						37x7.30

TABLE 3—TEN LINES OF BUSINESS SHOWING THE HIGHEST PERCENTAGE OF PROFIT-MAKING COMPANIES[5]

	Companies Reporting, No.	Companies Making Profit, Per Cent	Average Profit
1—Beverages and Spices	148	72.3	$71,296
2—Meat Packing	592	71.9	129,910
3—Ice Manufacturing	1,531	71.5	18,301
4—Gloves	31	70.9	6,034
5—Paper Containers, Boxes Bags, Wrapping	690	69.4	32,212
6—Milling, Flour, Feed, Meal	1,496	68.1	37,712
7—Furniture, all classes	1,597	67.3	30,607
8—Building Materials and Supplies	1,200	65.9	42,332
9—Canning, Fruits and Vegetables	1,035	65.5	41,623
10—General Printing, Publishing	8,009	65.0	29,424

[5] Data from Internal Revenue Bureau, Treasury Department.

is in fourth place. Taking the other side of the picture, Table 5, and analyzing it for the lines in which the percentage of losing companies is the highest, you will find that the automobile tire industry, with 64 per cent of losing firms, is in second place. It is exceeded by only the cotton-goods industry; and every one knows that the textile industry has been in a bad way for years. The motor-vehicle industry is third. If you look for the highest losses, where the losses of the losing companies are very high, Table 6, you will find that the tire industry is in sixth place. In other words, five other industries are worse off than the tire industry. The motor-vehicle industry is seventh. Table 7, which is a recapitulation of Tables 3, 4, 5 and 6, gives a sort of picture of the profits and losses in the principal lines of industry.

TABLE 4—TEN LINES OF BUSINESS SHOWING HIGHEST AVERAGE PROFIT[6]

	Average Profit per Successful Firm	Firms Reporting, No.	Companies Making Profit, Per Cent
1—Rubber Belting and Hose	$747,240	13	61.5
2—Locomotives	572,321	27	63.0
3—Sugar Manufacturing and Refining	449,097	235	52.7
4—Motor-Vehicles and Accessories	459,766	1,671	42.9
5—Artificial Leather, Linoleum	440,174	32	56.2
6—Tobacco	391,140	518	46.1
7—Automobile Tires and Inner Tubes	282,084	134	35.8
8—Carpets and Rugs	219,647	120	60.8
9—Cereal Preparations	176,747	194	57.7
10—Office and Business Equipment	150,850	309	60.5

[6] Data from Internal Revenue Bureau, Treasury Department.

The automotive industry has long prided itself on being one of the most successfully managed, successfully operated businesses in the Country. The statistics for 1925 have just come out and indicate that the industry was not much better off relatively in 1925 than it was in 1924. The situation in 1926 and 1927 remains to be seen, because the taxes are not paid until after the close of the calendar year and about a year is required in which to audit the reports and derive the statistical information so that it can be used.

TABLE 5—TEN LINES OF BUSINESS SHOWING HIGHEST PERCENTAGE OF LOSING COMPANIES[7]

	Companies Reporting, No.	Companies Showing Loss, Per Cent	Average Loss
1—Cotton Goods	976	65.0	$107,852
2—Automobile Tires	134	64.2	61,072
3—Motor-Vehicles	1,671	57.1	44,522
4—Airplanes and Parts	51	54.9	23,193
5—Silk Goods	708	54.7	47,126
6—Machine-Tools	667	51.9	27,139
7—Rubber Boots and Shoes	28	50.0	6,579
8—Celluloid and Ivory	98	49.7	18,638
9—Soaps	589	47.6	18,555
10—Boots, Shoes and Findings	1,280	47.3	31,174

[7] Data from Internal Revenue Bureau, Treasury Department.

TABLE 6—TEN LINES OF BUSINESS SHOWING HIGHEST AVERAGE LOSS[8]

	Average Loss per Firm	Companies Reporting, No.	Companies Showing Loss, Per Cent
1—Sugar Manufacturing and Refining	$148,325	235	47.3
2—Fertilizers	116,888	241	43.2
3—Cotton Goods	107,852	976	65.0
4—Meat Packing	93,540	592	28.1
5—Woolens and Worsteds	86,779	531	39.0
6—Automobile Tires	61,072	134	64.2
7—Motor-Vehicles	44,522	1,671	57.1
8—Locomotives	35,113	27	37.0
9—Musical Instruments	34,037	351	42.8
10—Butter Substitutes	31,911	27	51.9

[8] Data from Internal Revenue Bureau, Treasury Department.

To show what the different industries are, I shall refer again to Table 6, giving the average loss per firm. The number of firms reporting gives some idea of the relative loss per company. Sixty-four per cent of the companies in the tire industry, out of 134, showed an

TABLE 7—PROFITS AND LOSSES IN 1924 SELECTED FROM 50 INDUSTRIES[9]

Position	Highest Percentage of Profit-Making Companies	Highest Profit per Profit-Making Company	Highest Percentage of Losing Companies	Highest Loss per Losing Company
1	Beverages	Rubber Belting	Cotton Goods	Sugar Manufacturing and Refining
2	Meat Packing	Locomotives	Automobile Tires	Fertilizers
3	Ice Manufacturing	Sugar Manufacturing and Refining	Motor-Vehicles	Cotton Goods
4	Gloves	Motor-Vehicles	Airplanes	Meat-Packing
5	Paper Containers	Artificial Leather	Silk Goods	Woolens and Worsteds
6	Milling	Tobacco	Machine-Tools	Automobile Tires
7	Furniture	Automobile Tires	Rubber Boots	Motor-Vehicles
8	Building Materials	Carpets	Celluloid	Locomotives
9	Canning	Cereals	Soaps	Musical Instruments
10	Printing	Office Equipment	Boots and Shoes	Butter Substitutes

[9] Data from Internal Revenue Bureau, Treasury Department.

average loss of $61,000. Obviously, some companies lose a great deal more and some less. In the motor-vehicle industry, out of 1671 companies, which include not only car manufacturers but all the affiliated organizations, such as manufacturers of engines, frames, and accessories, and all the highly specialized plants that are subsidiary to the automotive industry, 57 per cent of the firms did not make money. In fact, they lost money to the tune of $44,000 each. That is a rather heavy tariff. No wonder that manufacturers are beginning to take keener interest in anything that will possibly reduce waste and save their rapidly shrinking margins of profit.

Company Mortality Rate High

A study was made of the number of firms remaining in the passenger-automobile industry, as in Fig. 1. The number of companies engaged in this business increased up to 1921, after which a rather sharp drop occurred. The years 1925 and 1926 would show relatively fewer companies than are indicated here. When analyzing the length of life of firms in the automotive industry, Fig. 2, you will note that 28 per cent of the 180 passen-

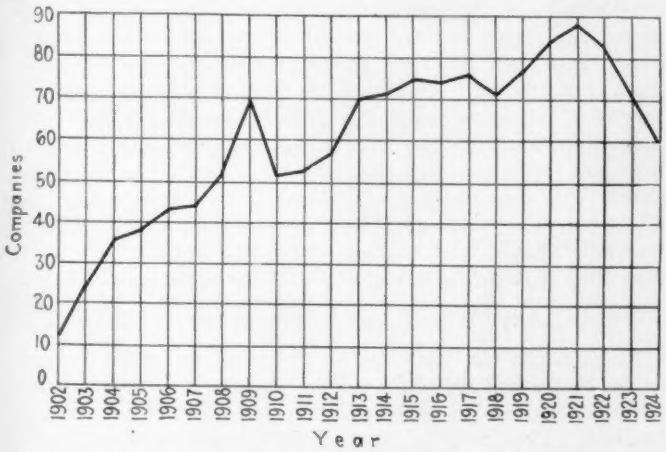


Fig. 1—Number of Firms Remaining in the Passenger-Automobile Industry

After a Decrease in the War Years, 1917 and 1918, the Number Increased to the Maximum in 1921, Since Which a Sharp Drop Has Occurred

ger-car manufacturing firms have a life of 3 years or less. Fifty-one per cent, which obviously include the first 28 per cent, have a life of 6 years or less. Only 34 per cent have had a life of 10 years or more, and only 20 per cent of the total number have been in business 16 years or longer. The mortality in this industry, as compared with some other industries, is relatively high.

In this period of growth and development, the increase in quantity production has been relatively rapid, as shown in Fig. 3. Discounting the war years 1917 and 1918, it rose rather rapidly in 1921 and 1922, and in 1923 reached the highest point, about 4,000,000 motor-vehicles. The years 1924 and 1925 were on about the same level. The total car registration has not increased at the same relative rate of expansion as in previous years. The average price per car has gone downward steadily since 1918; and the average percentage of profit per car in relation to the total sales is rather low compared with what it was some years ago. A slightly upward trend occurred in 1925, but whether 1926 or 1927 will show as good a percentage as did the previous years remains to be seen. The fact that the percentage may remain the same and the price average go down

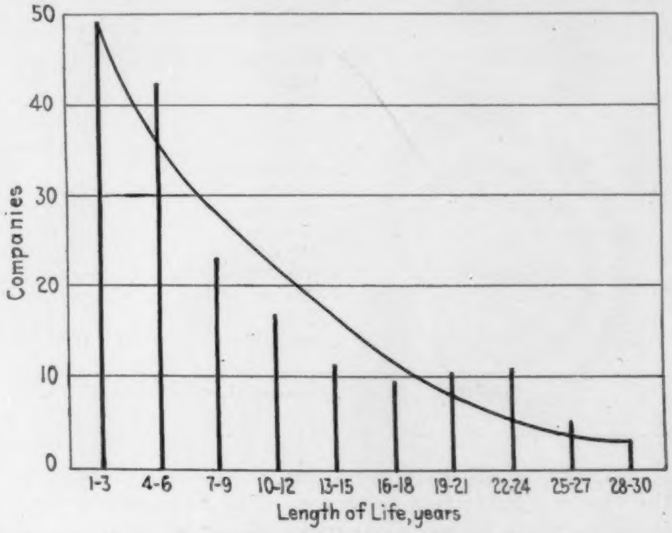


Fig. 2—Length of Life of 180 Passenger-Car Manufacturing Firms

Twenty-Eight Per Cent Have a Life of 3 Years or Less; 51 Per Cent, 6 Years or Less; Only 34 Per Cent Have Had a Life of More Than 10 Years, and Only 20 Per Cent of 16 Years or More

means that, to make the same net volume of profits, considerably more cars must be sold, and the question is whether so many more cars can be sold here at home. We seem to have reached the period of relative stability, somewhere around 4,000,000 cars a year. The main market from now on probably will not be among persons who have not had cars heretofore, but will be in the replacement or repeat-sales end of the business. The increment of increase due to new owners, that is, persons who have never had cars before, probably will be relatively small in proportion to the other part of the market.

Foreign and New Type Home Competition

It is always interesting to note in this connection that the foreign production increased considerably in 1926. Canada produced approximately 200,000 cars; so did Great Britain; and so did France. As those countries recover industrially and get back on their feet, we shall probably find our competition rather stiff, if we seek export business abroad.

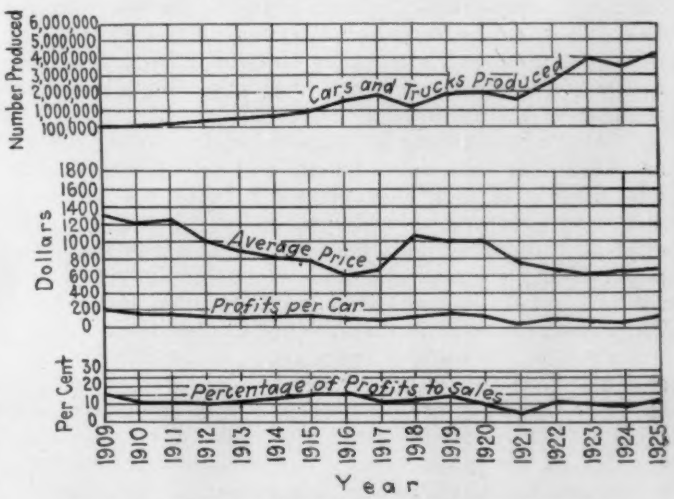


Fig. 3—Output of the Motor-Vehicle Industry

Increase in Quantity Production Has Been Relatively Rapid, While the Average Price and the Percentage of Profit Have Fallen Off

TABLE 8—DISTRIBUTION OF AUTOMOBILES, HOMES OWNED, AND HOME FURNISHINGS[10]

		Ratio per Family, Per Cent
Total Families	28,000,000	
Automobiles	21,000,000	0.75
Homes Owned	12,800,000	0.46
Phonographs	10,000,000	0.36
Pianos	6,000,000	0.22
Vacuum-Cleaners	5,000,000	0.18
Radio Sets	4,500,000	0.16
Refrigerators	4,000,000	0.14
Washing Machines	3,500,000	0.13

[10] Data on families and homes from Bureau of Census report for 1920, and on furnishings from *Advertising and Selling*, Nov. 2, 1927, p. 29.

Another factor that is having its influence today is the closer competition at home. The competition now is not so much between one make of car and another, as between the entire automotive industry and other industries. To prove that contention, it is necessary only to take cognizance of some of the concerted drives that have millions of dollars worth of advertising behind them, and of other promotional efforts that are being projected today by the different lines of business. In the matter of homes alone, many of you know of the Better Homes of America; others may know that the National Lumber Manufacturers' Association is spending $1,000,000 a year in promotional advertising to stimulate wider interest in the use of lumber, particularly in the building of more homes of lumber. The lumber industry is meeting competition from manufacturers of other kinds of building material, and so on down through the whole list. The industries concerned are trying to get a larger share of the consumer's dollar, and all are casting their attack more or less on the portion of the consumer's dollar that is now spent with the motor-car industry. The distribution of automobiles, homes owned, and home furnishings is shown in Table 8. I hear that from men in many different lines of trade whom I meet. The percentage of increase in families and in homes is based on the 1920 census.

Should Simplify to Eliminate Waste

Some way must be found to meet this kind of inter-industry competition; and it seems to me only logical that you should give closer attention to the elimination of waste through the further simplification and standardization of the components of your products that lend themselves to that kind of treatment.

I believe it is proper to improve the tire or the design as rapidly as new development and scientific research will allow. It is highly proper to give the public a steadily increasing value for its money; but doing that efficiently and effectively may call for closer cooperation between the members of the motor-car industry and the tire manufacturers than has prevailed heretofore. They must think in terms of other competition.

As you in the motor-car industry study this problem and find that subsidiary or related industries, such as the tire industry, the wheel and rim industry, and others, have problems that are induced by your insistence on too great variety in items in which variety is not absolutely necessary, but rather is an economic waste, you can do a great deal to help them solve their problems. If you can help the tire industry to simplify its lines, you will reap the benefit, not only in the lower cost of tires, but in gaining the good-will of the general buying public.

I am beginning to despair somewhat of the tire-simplification program and am beginning to think that it is in much the same category as Mark Twain's famous remark about the weather: "Everybody talks about it but nobody does anything about it." To do something about this situation, you do not need any more machinery. You can put into action such machinery as you have. It seems to me that a joint committee composed of representatives of the Society and of the tire industry could contribute to the solution of this problem, could work out a tentative list, at least, of sizes that would take care of all cars from the smallest to the largest, and from the lightest to the heaviest. In doing so it could project that list to the motor-car manufacturers and the tire companies to see what degree of acceptance it could get. It probably could not get 100-per cent acceptance at first, but, in these 80 simplification programs that I have mentioned, I have learned not to look for 100-per cent acceptance at the beginning. Acceptance of the recommended standard might be only 30 or 40 per cent. By acceptance, I mean the pledging of the different parties to concentrate their production on that program, and their agreeing to work along the lines of that simplification after a specified date; and then to work to get the simplification practices into effect. I have seen those degrees of acceptance increase. I have seen the adherence that I have referred to, that is, the percentage of products made to conform to the simplification standard, steadily increase. If you make a start and put a certain amount of sales effort and sales talk behind this program, you will get results, and, in the course of 1, or 2, or 3 years, this line, instead of being 30 or 40 sizes long, will be 10.

Department Will Help Simplification Program

As regards our part of the program, we do not claim to be technical experts and do not care to assume the responsibility of selecting the sizes that should be on the list. That is your part of the program. Obviously, the industry concerned must write its own ticket. When you are ready, we shall be glad to do all that we can, through such services as we have at our disposal, to help you get those standards into effect. We will help you sell them, help to get them adopted, and help complete your program. That form of cooperation and support from the Government has been helpful to many lines, and industry has benefited by it. I need say no more than that 11 industries have completed simplification programs of their own, which we have helped to put into effect, and report annual savings of approximately $300,000,000 a year. Some of these are listed in Table 9.

TABLE 9—TYPICAL INDUSTRIES THAT HAVE COMPLETED SIMPLIFICATION PROGRAMS

Industry	Varieties Reduced From	To	Estimated Annual Saving
Plow Bolts	1,500	840	$200,000
Die-Head Chasers, per cent	100	25	500,000
Paving Brick	66	5	1,000,000
Sheet Steel	1,819	263	2,400,000
Reinforcing Bars	40	11	4,500,000
Box-Board Thicknesses	244	60	5,000,000
Warehouse Forms	Thousands	15	5,000,000
Range Boilers	130	13	5,500,000
Inquiry-Invoice and Purchase-Order Forms	Thousands	3	15,000,000
Lumber, yard sizes, per cent	100	40	250,000,000
Total			$289,100,000

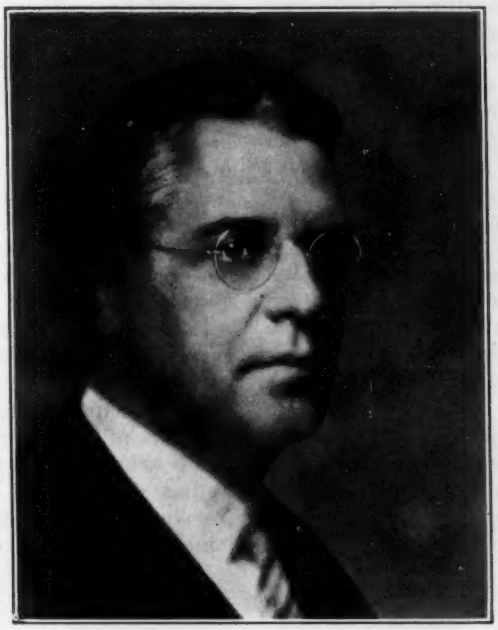
The Place of the Engineer in Industry

By A. R. Glancy[1]

Production Meeting Address

THE automobile industry has been a glorious achievement, developing in one generation from nothing to the largest industry, and carrying with this growth the most profound influence on the thought, feeling and social outlook of our time. Aladdin, who rubbed the magic lamp, was a mere fumbling amateur. In this amazing growth, things probably have happened and acts have been committed that are hard to reconcile with clear business ethics; but we must remember that there are periods in the life of an individual, a corporation or an empire which are similar.

First comes the stark necessity of getting a position, a ruthless time when no holes are barred; then an intermediate period of making this position secure; and then the period we are now entering, when mature judgment reigns, when policies are respected. This marks the passing of the old-time pioneer, the day of individual combat, individual decisions and erratic performance. I am sure our industry is in the third period. With that period has come the problem of selling, a problem not only for our business, but for American industry as a whole; and it is one in which the engineering profession can be of inestimable value.



A. R. Glancy

Samuel Strauss makes the point that we no longer produce in order to sell; we sell, we must sell in order that we can continue to produce, in order to support this stupendous economic structure called the American public. The first condition of our civilization concerns itself with production. It is not that we must turn out large quantities of things; it is that we must turn out larger quantities of things, more this year than last, more next year than this. The flow from mill and mine must steadily increase. He states that, while there are a thousand programs brewing throughout the Country, and a thousand isms and causes and parties, each with its own notion of what must be done for the National good and the human good, while they all are at war with one another, they all have one thought in common. The Nation's standard of living must not sag back; and, while the capitalists and the socialists are at each other's throats, the issue between them is, which one can assure the distribution of the most good. National prosperity, our standards of living, must be held where they are; they can be held there only by industry, which is production; and we can have production only after we have sales.

Consumptionism is a new science. Through the centuries the problem has been how to produce enough of the things men wanted. The problem now is, how to make men want and use more than enough things: the science of plenty, Mr. Strauss calls it. The problem before us today is not to produce the goods, but how to produce the customers.

So, if we accept the premise that sales are a paramount issue, and if we broaden our definition of sales efforts so that it starts on the drafting-board, we begin to see where the engineer fits in. Grant that the piece is strong enough, has a selling appeal designed in it; take it to the production department, grant that it is machined within the tolerances, has that certain "it"; take it to the sales department, will it be distributed in a scientific manner?

Who is in a better position than the engineer to succeed to the positions at the top of this business? I do not advocate making mediocre salesmen out of good engineers; but I believe that the engineer's influence should be strongly felt in all departments and that the engineer should be called upon to fill more of the general directing positions than he has filled in the past. He is of the type; his exact training enables him to build a sturdy skeleton structure of certainty which the sales department can adorn with variegated colorful effects; to which the advertising department can swim back in safety after one of its deep dives into the Baron Munchausen pools of engineering data.

The engineering profession is the most romantic of all professions and we should be deeply sympathetic with sales; but many of us pride ourselves on our case-hardened exteriors. How many of us began to study engineering because of an unexpressed desire to see distant places, to meet strange people, and to live under strange customs. The selling side is always a romantic side and should find a warm spot in our hearts. You know the old "ballyhoo" is what brings the customers into the tent.

The human equation is most important, because it always solves the x of business success or failure; the engineer is well equipped to evaluate this human equation. You are mentally trained. In acquiring that training, you have associated with cultured people, you enjoy daily contact with forceful and successful people, and, at the same time, you are able to stand up against a bench and sweat and chew tobacco with the toughest lad in the shop. Yours is the almost rounded contact;

[1] President, Oakland Motor Car Co., Pontiac, Mich.

I say almost because I believe you do fight shy of the selling side; that is the other fellow's job. But we are in this business not to design automobiles, or to build automobiles; our business is to sell automobiles at a profit.

I suggest that we all become salesmen; if no direct personal benefits accrue, we shall bring our dealers closer to us and strengthen our industry as a whole. I hazard a guess that your conception of the dealer's needs today is a strengthened service-department. The annoying field complaints that come in from dealers could, in the minds of the engineering department, all be solved, if that dealer only had a cracker-jack service-manager and ample shop facilities. As a matter of fact, that trouble is secondary; his primary trouble is lack of an accounting system, because, when you suggest to that dealer that he get this good foreman and improve his shop, he will begin to complain that he is losing so much money in that department now he cannot afford to spend more money there; yet, if you men knew enough about the accounting side of this business, you could prove to that dealer that, with an accounting system which would give him an accurate monthly financial statement promptly, show the financial position of all the phases of his business, show what seemingly unavoidable losses could be minimized or actually changed into profit, he would be striking at the root of the trouble, and you could show him why he could afford to hire the better man. Accounting is an exact art toward which the engineer should have a natural sympathy.

Making everyone a salesman is a practice with us. I cannot claim that we can make a salesman out of every engineer, but we encourage his latent ability to blossom forth. When our sales department holds large dealer meetings, our engineering and production departments go along and occupy major positions on the program. As a result, they come back with dealers' sympathies and ideas for dealers' support; as a result of this intensive sales effort, our engineering department is in a most enviable position. It can stay at home and criticize the production department; it can travel around and criticize the sales.

I have read discussions[3] of the engineer's place in the industry. You will find that I have touched upon most of the points mentioned, yet the 6 years that have elapsed have given the points different weights. The sales-department engineer apparently was a 1921 worry. Cars should be designed with the full cooperation and support of the sales department, but the old sales engineer has, I believe, passed out of the picture. I remember, when I was head man at the Samson Tractor obsequies, we had three engineering departments, but we put plain bearings in the front wheels because the sales department maintained that the farmer would grease only what squealed.

Some of my deductions may be wrong, because, like a fish in the sea, I am so deep in it I cannot tell how rough it is; but I accept the engineer as the most potent force in this business. His is the trained mind that can be educated in the fundamentals of business and, once he has an understanding of what the functions and operations of the business machine are, the engineer will make even more rapid strides toward full control than he has since 1921. Fundamentally, this is an engineering industry and the fruits of the harvest must be yours.

[3] See Engineering as a Profession and the Value of an Engineering Education, by H. M. Crane, THE JOURNAL, May, 1921, p. 496.

Natural Gas

THE natural-gas industry in the United States continued to grow slowly but steadily in 1926 when 1,313,019,000,000 cu. ft. of gas was produced and delivered to consumers, an increase of 10 per cent over 1925. Of this amount 166,000,000 cu. ft. was piped to Mexico and Canada, and 1,312,853,000,000 cu. ft. was consumed in the United States in 1926. The value of the gas per 1000 cu. ft. at the wells increased from 9.4 cents in 1925 to 9.5 cents in 1926, and at points of consumption from 22.3 cents in 1925 to 22.8 in 1926. Neither of these figures, however, equaled those of 1923 or of some previous years.

Domestic, that is, household, consumers used 22 per cent of the total consumption of natural gas in 1926, and industrial organizations 78 per cent. This indicates a slight growth in amount consumed by the latter in 1926. The total value of domestic consumption, however, was greater, as domestic users paid an average of 58.1 cents per 1000 cu. ft. as compared with 12.8 cents by industrial users. In 1926 there were 3,731,000 domestic consumers of natural gas, as compared with 3,508,000 in 1925. This represents a gain of 223,000, which is, with the exception of 1913 and 1922, the largest yearly increase ever recorded. California and Texas each recorded an increase of about 70,000 in number of domestic consumers and far surpassed the other States in this respect.

The relative rank of the three chief gas-producing States was unchanged in 1926. Oklahoma, which ranks first, recorded a 15-per cent gain in output; California, which ranks second, a 9-per cent gain; but production in West Virginia, the next ranking State showed a slight decrease. Texas registered a material gain in output and not only took fourth place from Louisiana but threatens to displace West Virginia in the near future.

The tendency to extract the greatest possible amount of natural-gas gasoline from natural gas before consumption of the gas was very marked in 1926. A total of 1,206,300,000,000 cu. ft. of natural gas was treated for the recovery of natural-gas gasoline in 1926, which is equivalent to 92 per cent of the total production. In 1925 the proportion treated was 88 per cent.

The total consumption of natural gas, including residue gas from natural-gas gasoline plants, by industrial users in 1926 amounted to 1,023,678,000,000 cu. ft., an increase over 1925 of 12 per cent. The consumption of natural gas for field and industrial uses exclusive of carbon black, again showed an increase.

Oklahoma, because of its importance as a producer of petroleum and natural-gas gasoline, ranked first among the States in the use of natural gas for field purposes; that is, for drilling, pumping and operating natural-gas gasoline-recovery plants. Louisiana, by reason of being the chief carbon-black producer, led in the consumption of natural gas for "other industrial" purposes.

The interstate movement of natural gas in 1926 amounted to 209,527,000,000 cu. ft., a slight increase over 1925. The movement from West Virginia to Ohio and Pennsylvania continued to be of first importance. Of more than passing interest was the increase in the counter movement of gas from Ohio to West Virginia.—G. R. Hopkins, for the United States Bureau of Mines.

Lacquer Surfacers

By C. D. Holley[1] **Cleveland Section Paper**

THE finishing of automotive products with lacquer is still in the transition stage, according to the author. Sufficient time has not elapsed to provide an adequate background of experience which establishes principles and practices that fully meet the requirements of the production engineer. In other words, many of the things we think we know about lacquer finishes and lacquer undercoatings are either not true or are correct in part only.

The general function of a surfacer is to provide a smooth surface for the finishing coats. Inasmuch as the larger part of the material applied to provide such a surface must be cut away by sanding so as to bring the surface as a whole to the requisite smoothness, a satisfactory surfacer is one that can be applied with the minimum effort, can be sanded with the minimum amount of labor, and can be purchased cheaply, the reason being that most of it is carried away by the wash water during the sanding process. Ease of application and of sanding are essential characteristics of a good lacquer surfacer but, to the author's mind, the proper relation of the surfacer to the primer and to the finishing coats of lacquer enamel is the basic requisite.

To present a clear idea of the relation of a surfacer to the finishing system as a whole, the elements of former practices are reviewed. The author then discusses the basic relations which exist between the lacquer enamel and the surfacer. First, the surfacer must not absorb the lacquer enamel except to a very limited extent. Second, the lacquer enamel must adhere firmly to the surfacer. Some lacquer enamels contain so much oil and plasticizer that this is difficult to accomplish and many materials which otherwise would be advantageous in surfacers tend to reduce the adhesion of the enamel to the surfacer. It is, therefore, obvious that the composition of the surfacer and of the lacquer enamel should bear a very definite relation to each other.

In conclusion, the author says that, notwithstanding their higher cost and lower "building value," lacquer surfacers have come to stay because of their quick-drying and easy-sanding qualities. The remarkable progress already made in the development of lacquer surfacers and the continued activity in improving and perfecting them justifies not only the close attention of the automotive engineer but also a definite share of his time and energy in adapting production operations to bring about the most successful usage of lacquer.

The discussion includes definitions of the terms used in connection with lacquer and answers to numerous questions relative to details of lacquer composition and application.

A SURFACER is a coating which provides a smooth surface for the finishing coats. Inasmuch as the larger part of the material applied to give such a surface must be cut away to bring the surface as a whole to the requisite smoothness, it is becoming the fashion to regard a surfacer as something to be applied with the minimum of effort, to be "cut down" or "sanded" with the minimum of labor and to be purchased cheaply because the greater part of it goes down the sewer with the wash water. It is true that ease of application and ease in sanding are essential characteristics of a good lacquer surfacer; but, to my mind, the proper relation of the surfacer to the primer and to the finishing coats of lacquer enamel is the first or basic requisite of a lacquer surfacer. To obtain a clear idea of the relation of a surfacer to the finishing system as a whole, let us review the elements of the old system, taking as our example a system high class in every respect.

(1) A long elastic oil primer-coat, thoroughly "air" or "force" dried

(2) A split coat, or a half-and-half coat composed essentially of half primer and half surfacer, since experience has determined that a long oil primer-coat in contact with a relatively inelastic surfacer of the oil-varnish type would not knit together as firmly or withstand the strain of continual expansion and contraction as well as when an intermediate coat, having a measure of the characteristics of both coats, was employed. In brief, the split coat equalized the stress-strains which the surfacer otherwise would have had to meet at the point of contact with the primer

(3) The surfacer coats, as many coats being applied as are necessary and then sanded down to the required smoothness of surface

(4) The color ground-coat, which served as a color ground and a sealer to prevent excessive absorption of the color varnish

(5) The color varnish-coatings of reasonable length and elasticity

(6) The clear, or finishing, varnish

The primer was very elastic so that, being next to the metal and bonded to the metal, it would withstand any sudden expansion or contraction of the metal as when a car is driven out of a warm garage into zero weather, causing a very sudden contraction of the metal and setting up a severe strain in the finish.

The split, or intermediate coat was not as elastic as the primer but was considerably more elastic than the surfacer coats. The surfacer coats were very brittle. A surfacer film, if it were bent slightly, would break. The color ground-coat was more elastic than the surfacer; then the color varnishes and the finish varnish were applied.

Why did the color ground-coat and the finish varnishes need to be so elastic when they were applied over relatively inelastic foundations? Because the finishing varnish and the color varnish become very much less elastic after a few months or after a year or so, depending on their quality. As the automobile continued in service, the elasticity of the top coats approached more nearly that of the surfacer coats, the primer coats remaining relatively long and elastic. And that was the story before competition began to be so keen. Such a system equalized the stresses due to the daily expansion and contraction of the metal itself and also the equally

[1] Director of paint research, Acme White Lead & Color Works, Detroit.

powerful film-strains produced by the progressive oxidation of the top coats and their tendency to shrink.

But competition, lack of floor space and increased speed of production resulted generally in shortening the primer and eliminating the split coat, entailing the use of a shorter surfacer, the elimination of the ground-coat short color-varnishes and the application of a faster-drying finishing-varnish. Reduced to its simplest elements, the system consisted of primer, surfacer, color and varnish coats. Through the ingenuity of the paint maker and through forced drying or low-temperature baking, this sort of system gave a wearing value that avoided serious complaint from the public because, having gradually become accustomed to poorer wearing finishes as prices declined, the public linked these two features together and made little fuss about it. At about this time, lacquer enamels and lacquer finishes made their appearance. The lacquer enamel replaced both the varnish color-coats and the finishing varnish on the popular-priced cars, although varnish finishing-coats were continued over the lacquer for a time on some of the higher priced cars. Soon, lacquer primers and lacquer surfacers made their appearance, and this resulted in a so-called complete lacquer system.

The point I wish to make is that such a system was arrived at by replacing oil primer with lacquer primer, oil-varnish surfacer with lacquer surfacer, and color and finishing varnish with lacquer enamel, in a system in which the different coats were not properly correlated to each other. In other words, the lacquer systems of today, as I know them, have not been developed as a completed whole in which each coat bears its proper relation to each of the other coats and in which the stress-strains are properly equalized and spread throughout the system and not localized at the interfaces of two coats. How could we expect to obtain a thoroughly satisfactory system by replacing units of such a poorly constructed system?

Lacquer-Surfacer Requirements

To obtain a better understanding of the requirements of a lacquer surfacer, we must recognize that it is an intermediate coat and is primarily dependent on the character and quality of the primer used underneath. With our present-day conception and understanding of lacquer surfacers, should we use an oil primer or a lacquer primer as the best foundation for the surfacer? In arriving at the answer, let us determine what features in a primer are of paramount importance.

Permanence of adhesion, flexibility and elasticity should head the list. Anything which would impair one of these requisites impairs the value of the whole system. But here we meet our first difficulty. The solvents used in the manufacture of lacquer surfacers and in reducing them for spray application partake of the character of paint removers; that is, they soften and loosen oil and varnish coatings. This is particularly true of oil primers which are air dried; but, oil primers which have been thoroughly force dried or baked resist this softening action to a marked degree.

Oil primers develop their adhesion to the metal through the oxidation or drying of the linseed, chinawood or perilla oils contained in the vehicle by which these oils pass from the liquid phase to the solid phase. If these oils are again partially liquefied by application of lacquer solvents, the adhesion to the metal is destroyed and, as the solvent evaporates, this adhesion is again restored to a fractional degree only. When a primer is baked, the baking process removes the volatile oxidation products from the film, as well as the final traces of turpentine or turpentine substitute, and advances the oxidation of the oils to the final stage leading a very impervious, closely knit, coherent film, which resists the action of the lacquer solvents so that, in the short time the solvent is present, it does not soften and destroy the bond of the primer to the metal, or impair its permanent elasticity.

Lacquer primers dry through evaporation of the solvent present and not through any oxidation of the oils present. They develop their maximum adhesion as soon as the solid phase is reached. This adhesion is not materially impaired if the film is again softened through contact with lacquer solvents. This point of superiority over oil primers should justify the general use of lacquer primers, were it not for the fact that lacquer primers, as I know them, lose in adhesion after being in service. The critical point may not be reached for weeks, months or even a year.

Why lacquer primers lose adhesion is not clearly known. We do know that there is a pronounced shrinkage strain set up in a nitrocellulose film which tends to pull the film loose. We know that such a film holds much better over a sand-blasted surface, where the film has innumerable anchor points due to the roughness of the metal, than it does over a sheet of smooth steel. We also believe that oils and plasticizers present in the film or in the system, travel and move around more or less and that this explains some of the peculiar conditions we observe from time to time. Further, adhesion, particularly permanent adhesion, is not a general function of oils, gums, plasticizers or nitrocellulose, but is a specific quality of certain oils or other components of a film. If the components selected do not possess this specific quality or if one component is positive and another negative in this respect, permanence of adhesion is poor. This, I believe, is the reason that lacquer primers have not been more successful. The components which have been available with which to construct or formulate a lacquer primer, did not possess this specific quality of adhesion to the required degree. It has taken time for the lacquer manufacturer to realize this fully. We believe that now we are on the threshold of producing components which will accomplish adhesion and, in this, we as paint engineers must place ourselves in the hands of synthetic organic chemists who have been working in related but different industries. As their development of these products proceed, so will successful lacquer-primer formulation proceed.

In concluding this phase of the subject, I consider that oil primers which have been baked or thoroughly force dried are preferable to lacquer primers as a foundation coat for lacquer surfacer, although developments may change this situation overnight.

Lacquer Enamel and Surfacer Relations

Assuming that the surfacer provides a smooth surface free from objectionable scratches, what basic relations exist between the lacquer enamel and the surfacer? Two such relations are immediately obvious. The surfacer must "hold out" the lacquer finishing enamel to the required degree; in other words, it must not absorb the lacquer except to a very limited extent. Second, the lacquer enamel must adhere firmly to the surfacer. Some lacquer enamels contain so much oil and plasticizer that this is a difficult thing to accomplish and many materials which otherwise would be ad-

vantageous in surfacers tend to reduce the adhesion of the enamel to the surfacer. It is therefore obvious that the composition of the surfacer and of the lacquer enamel should bear a very definite relation to each other.

A third relation exists that is by no means well understood and probably will not be removed from the field of conjecture until the physical chemist takes over this problem. When an oil-varnish surfacer was applied over an oil primer, they both remained as separate entities; the primer absorbed none of the materials in the surfacer and vice versa, and, when a color-varnish ground-coat was applied over the surfacer, the varnish vehicle as such was absorbed to a certain extent; but there was not what we could call selective absorption of the vehicle components.

With lacquer products, we have reason to believe that there is an interchange in certain of the components between the primer and the surfacer. We also have reason to believe that there is considerable selective absorption between the surfacer and the lacquer enamel. Obviously, this traveling about the various individual components of a lacquer system will vary according to the conditions of application. For instance, if the successive coats of surfacer be applied one right after the other, as rapidly as possible without sagging, the volatile thinner-content is highly concentrated in a film for a sufficient time to cause maximum penetration into the primer. This volatile thinner does not enter the primer film in a pure form but carries some of the soluble constituents of the surfacer along with it, such as oils, plasticizers and the like.

When this volatile thinner again leaves the primer and passes up through the surfacer film, what happens? If the pigments and other components of the primer possess selective absorption, and there is good reason to believe they do, some of the surfacer components will remain in the primer film and it is possible that some of the primer components pass into the surfacer film. The same type of absorption and interchange will, we have reason to believe, take place to a much greater degree between the surfacer and the lacquer enamel. When we load one wet coat of lacquer enamel on top of another and thereby set up a high solvent-concentration at the point of contact between the enamel and the surfacer, we have reason to believe that the surfacer acts as a permeable or semi-permeable membrane.

It is evident that we have a very interesting problem on our hands when we try to evaluate the true relation of the different coats of a lacquer system. We are, however, making progress. We know some of the usable components which are, to use a common expression, pushed around the least, and we know something of those which have pronounced traveling propensities.

Since the manufacture of lacquer surfacers, especially for automobile production plants, is a comparatively recent undertaking, a large part of the development has been by the trial-and-error method, and probably about as many different compositions are being marketed as there are men formulating them, an opinion which is confirmed by a recent survey I made. But there are some phases on which there is common agreement. Special efforts have been made to overcome objectionable settling in the spray bucket or container after the reduction has been effected. This has brought into use a number of pigments not hitherto widely used in this phase of the paint industry.

The best oil-varnish surfacers contained essentially about two-thirds white lead and one-third Keystone filler for the pigment portion. This, when properly sanded, gave a very smooth, closely knit surface of low porosity. Such a surfacer commanded a rather high price and required considerable labor to "sand." The more general practice was to use 30 to 50 per cent white lead with a corresponding increase in the filler. This gave an easier-sanding product at lower cost, and the film was more porous and less flexible.

Both these pigments settle rapidly when used in lacquer surfacers and a combination of three or four pigments is now generally used in their place, each of which plays its definite part. One or more possess marked suspending properties. Another is used to regulate the ease of sanding and reduces the tendency to "gum" the sandpaper. A third may reduce the tendency to form objectionable scratches and a fourth may be selected because it has a high volume displacement with a relatively low oil-absorption value which permits the use of less thinner in obtaining spraying consistency. From this explanation, it is obvious that we do not know of any one or two pigments which meet the requirements in every respect. Lacquer manufacturers, therefore, have been trying to work out a combination of pigments which best meets each angle of the situation.

When we come to consider the vehicle combinations most suitable for lacquer surfacers, there is even a wider divergence of opinion as to the components which should be used. It is, however, generally agreed that the percentage of varnish gums should be very low if suitable flexibility is to be maintained. On the other hand, there is a natural desire to use varnish gums as they help to "hold out" the lacquer enamel with a higher natural gloss.

The use of raw or untreated oils increases the tendency to "gum" the sandpaper; so also do excessive quantities of plasticizer. They may also impart added softness to the lacquer-enamel film for reasons previously mentioned. However, just what treated or processed oils and what particular plasticizer should be used, and the quantities of each to obtain the maximum beneficial effect, have not as yet been fully determined, at least not to my satisfaction.

Generally speaking, since the combination of the oil and plasticizer has the greater volume displacement per unit of weight and promotes flexibility and easy sanding, the maximum amount should be used that is consistent with maintaining the other desirable qualities.

Naturally, much depends on the amount of nitrocellulose present and also, particularly, on the viscosity. It is generally understood that the use of a nitrocellulose of a viscosity much above 0.5 Saybolt sec. will require an excessive reduction with reducer to bring it to spraying consistency. This, of course, means a waste of reducer and a low "building value" per coat. If too much nitrocellulose is used in proportion to the oil and plasticizer, the sanding becomes very hard with an increasing tendency for objectionable sand scratches. If the nitrocellulose content is low, "gumming" of the sandpaper will occur provided the oil content is high. If the oil content is also low, the surfacer is likely to check and crack, especially if it is not immediately coated with the lacquer enamel.

This brings us to one very important consideration; namely, that having shown that a lacquer surfacer is a carefully balanced product, the composition must be kept uniform during application. If the contents of the spray bucket or pressure tank are not kept agitated

during application, there will be lack of uniformity in the material sprayed on the job. The paint manufacturer endeavors to introduce a reasonable margin of safety in his formulation and in his products, but if the material in the bottom of the spray bucket has an abnormally high concentration of pigment through settling, a porous coat of surfacer is likely to be obtained which will check or crack or cause the lacquer enamel to "sink in" to an undesirable extent.

In judging the value of a surfacer and balancing that value against the purchase cost, we should not be misled by a laboratory chemical analysis which reports the solid content by weight, as a surfacer may contain a lower solid content by weight and yet have a greater building value than one of a higher content by weight. This difference is, of course, based on the differences in volume displacements of the components used.

Let us consider for a moment the two lacquer surfacers shown in Table 1.

The figures in Table 1 illustrate the fact that the majority of chemists, paint representatives and lacquer manufacturers are inclined to talk of their lacquer surfacers in terms of percentage by weight, the inference being that the representative who can claim the greatest percentage by weight has a surfacer that will build up the most on the job. But this does not follow; he may or he may not, as shown in Table 1. It can be the reverse.

The better grades of oil-varnish surfacers contain about 80 per cent pigment and between 85 and 90 per cent total solids by weight. The best types of lacquer surfacers contain 58 to 68 per cent total solids by weight. However, as has been pointed out, percentages by weight do not serve as a measure of the surface-building value.

On a volume basis, the better oil-varnish surfacers consist of about 40 per cent pigment, 40 per cent oils and varnish gums, and 20 per cent volatile content. The ones used on the popular-priced cars usually contain 30 per cent or more of volatile content by volume, mostly at the expense of the oil and varnish-gum volume. As compared with these figures of 70 to 80 per cent, lacquer surfacers usually contain 35 to 40 per cent of total solids by volume. I have gone into this phase of the subject rather carefully because many engineers do not understand why a lacquer surfacer does not build up as rapidly as the old type of surfacer.

Another feature which affects the surface-building value, and which should not be lost sight of, is the somewhat greater amount of reduction required by lacquer surfacers than oil surfacers; it is about 100 per cent to 120 per cent for the former as against 75 per cent to 90 per cent for the latter.

The basic reason for the difference in surface-building value between lacquer surfacers and oil surfacers, is of course due to the much higher viscosity of the nitrocellulose solution as compared with an oil-varnish vehicle, per unit of solid content. Therefore, to obtain the required nitrocellulose content of the lacquer surfacer, a relatively large volatile content must be used, which occupies volume at the expense of the total solid-content. I believe that much will be accomplished during the coming year to overcome this defect. Surfacers of a volume-building content of 50 per cent or even 60 per cent, with a reduction for spray application no greater than that of the old type of surfacer, are possible and even probable in the near future. Notwithstanding their higher cost and lower surface-building value, lacquer surfacers, by reason of their quick drying and easy sanding qualities, have come to stay. "Speed of production" seems to be the god on whose altar modern Industry lays her choicest gifts and those of the lacquer manufacturer are not among the least.

The remarkable progress already made in the development of lacquer surfacers, and the continued activity in improving and perfecting them, justify not only the close attention of the automotive engineer, but also a definite share of his time and energy in adapting production operations to bring about their most successful usage.

TABLE 1—COMPARISON OF TWO LACQUER SURFACERS

Lacquer Surfacer *A*		Lacquer Surfacer *B*
Composed of pigments of low oil-absorption and low volume-displacement or bulking value.		Composed of pigments of medium oil-absorption and fairly good volume-displacement or bulking value.
	Percentage by Weight	
66	Non-Volatile Solids	60
34	Volatile Content	40
100		100
	Distribution of Non-Volatile Solids	
55	2.6 Gal. per 100 Lb.—Pigment Volume Displacement— 4.5 Gal. per 100 Lb.	39
1	10.0 Gal. per 100 Lb.—Varnish Gums or Resins Volume Displacement—10.0 Gal. per 100 Lb.	3
10	11.2 Lb. per Gal.—Weight of Oils, Plasticizers and Nitrocellulose—11.2 Lb. per Gal.	18
66		60
	Average Volatile Content	
34	7.1 Lb. per Gal.—Mixture of Volatile Thinners—7.1 Lb. per Gal.	40

Lacquer Surfacer *A*		Lacquer Surfacer *B*	
Therefore, we have:	Gal.	Therefore, we have:	Gal.
5.50×2.6	= 14.3	3.90×4.5	= 17.6
0.10×10.0	= 1.0	0.30×10.0	= 3.0
100 Lb. ÷ 11.2 Lb.	= 8.9	180 Lb. ÷ 11.2 Lb.	= 16.0
	24.2 Solids		36.6 Solids
340 Lb. ÷ 7.1 Lb.	= 48.0 Volatile	400 Lb. ÷ 7.1 Lb.	= 56.3 Volatile
	72.2		92.9

Percentage of Non-Volatile Solids by Volume

Lacquer Surfacer *A*	Lacquer Surfacer *B*
(24.2 ÷ 72) 100 = 33.5	(36.6 ÷ 92.9) 100 = 39.3
This Indicates That, of the 231 Cu. In. in a Gallon, One-Third, or 77 Cu. In., Is of Actual Surface-Building Value Equivalent to an Area of 8½ Sq. Ft. 1/16 In. Thick or 17 Sq. Ft. 1/32 In. Thick	This Indicates That, of the 231 Cu. In. in a Gallon, 39.3 Per Cent, or 91 Cu. In., Is of Actual Surface-Building Value Equivalent to an Area of 10 Sq. Ft. 1/16 In. Thick or 20 Sq. Ft. 1/32 In. Thick

THE DISCUSSION

G. W. SMITH, JR.:—What is "Keystone" filler?

C. D. HOLLEY:—Keystone filler is a natural pigment, that is, a natural kind of rock which might be described as a cross between slate and soft coal. It carries about 11 per cent of carbon and about 89 per cent of silica or silicate and most of it comes from the vicinity of Muncie, Ind. It is a product which has rather a sharp "tooth" to it, and yet it is soft and can be sanded or cut away easily. Probably the terms "Keystone filler" or "Muncie filler" or "filler" are not so well recognized outside of the paint factories.

MR. SMITH:—What oils are used in lacquer surfacers?

MR. HOLLEY:—They may be of two kinds. The non-drying type of oil is most commonly castor oil. Probably most lacquer surfacers contain castor oil. The other oils which they may contain are of the semi-drying type, such as soya oils, for instance. Possibly some people are using the same type of oil that they would use in the oil surfacers, that is, linseed or perilla oils. I think Chinawood oil is not generally used. Oils other than castor oil are being used, but I do not know to what extent.

MR. SMITH:—What is meant by "plasticizers," and what are the plasticizers used?

MR. HOLLEY:—Three common plasticizers are used in the manufacture of lacquers, whether in finishing enamel, in lacquer primer or in lacquer surfacer. One has largely passed out of use. It was used a few years ago and is an organic compound that went by the name og butyl tartrate. Some manufacturers may use it still. Probably it passed out of use because of its proclivities for reversion; that is, the development of free acid. The two that are commonly used are tricrecyl phosphate and dibutyl phthallate, both organic compounds that the lacquer manufacturer must depend upon the commercial organic chemist to provide. They have about the consistency of a rather thin oil.

MR. SMITH:—What are the varnish gums?

MR. HOLLEY:—The old-time oil-varnish surfacer had for its gum content, almost invariably, what we call fossil gums, that is, gums which were produced on an evergreen tree which flourished some thousands of years ago. The tree died, decayed and was buried in the sand, and the gum remained and was dug up by the natives. Probably all the high-grade oil-varnish surfacers carry gum as their basis. The gum used in the lacquer surfacer is generally of two types, what we know as the damar gum and ester gum. Ester gum is resin chemically combined with glycerin to a neutral composition. Those gums are both characterized by easy sanding and both of them are very neutral. They will not set up an acid condition and are neutral with regard to the other constituents present.

MR. SMITH:—Are the lacquers mostly nitrate lacquers or acetate lacquers?

MR. HOLLEY:—Lacquers for outside application to airplane fabrics and practically all the lacquers used in the automotive industry are nitrate lacquers. If there is any acetate cellulose being used in automobile coatings, I do not know of it, I think they would not be used because they are very much more expensive and require a different solvent mixture for their use and application than do the nitrocelluloses.

MR. SMITH:—What is the difference between lacquer suitable for application to wood and lacquer suitable for application to metal?

MR. HOLLEY:—Application of the lacquer system to wood and its application to metal are very different propositions. We think that we understand how to make a lacquer system that can be applied to metal and which will have good durability, a moderate cost and require only a short interval of time between the beginning and the completion of the job; but, so far as I know, that does not appertain to wood. I hesitate to recommend any lacquer system of today for the finishing of wood that is to be exposed continuously to the weather unless the manufacturer or the production engineer was willing to allow nearly as much time for application of that system as would be needed for the old-type oil-primer, oil-surfacer-and-varnish system. It seems to be a fact rather definitely established that, to have a lacquer system successful in its application on wood, there be thorough penetration of the surface fibers of the wood by some material which will not only penetrate but will remain and seal the upper section of the wood, or the section near the surface, so that moisture cannot penetrate and cause those fibers to swell. It seems to be the swelling of the fibers on account of moisture that wrecks a lacquer system when applied to wood. But if we can get the fibers near the surface so thoroughly impregnated with some material that they will not swell when there is absorption of moisture, the lacquer may be successful, because we must remember that no coating, unless it be a solid sheet of metallic alloy or tinfoil, is absolutely moisture proof. Even several coats of the best spar varnishes will let an appreciable amount of moisture through. However, unless we can get the fibers thoroughly impregnated with some material that will not absorb moisture, I think a lacquer system on wood will go to pieces in a relatively short time.

J. WEBB SAFFOLD:—What effect do hot water and steam have on a lacquer surface, especially on a cold day?

MR. HOLLEY:—I would not expect any serious consequence from hot water. The continued application of live steam would wreck the film within a relatively short time. The whole thing hinges largely on whether the stresses have been equalized between the different coatings of lacquer. The lacquer enamel is resistant enough to steam and it is resistant enough to hot water, but it is the stresses set up in the other coatings that cause trouble. The lacquer system of today was a replacement, coat for coat, of an abbreviated system which competition had forced into the industry and which was not adequate for the requirements of the industry, because it did not equalize the stresses and great strains existed at the points of contact of two or more of the coats.

E. G. KERR:—Are there any better practical methods of obtaining the surface-building power of the surfacer other than the solids?

MR. HOLLEY:—In each gallon of surfacer bought there is a content of volatile matter, which evaporates and passes into the air when it is applied to the job, and a content of total solids, which remain on the job. The building content lies wholly in the total solids.

As to how the purchaser of a lacquer can determine whether it has good building quality, probably as good

a way as any is to produce a sizable area of surfacer by spraying several coats of it onto sheets of tin which have been coated with quicksilver. This produces a lacquer-surfacer film. Spray about three or four coats of lacquer surfacer on the tin and then determine the specific gravity of the resulting films. The building content is calculated from the specific gravity. It is more or less a mathematical proposition. You cannot take a certain amount of lacquer and spray it on a given surface, because more or less would be lost in the air and the expense of doing that would be considerable; but, through the specific gravity of the lacquer film and through a determination of its inorganic content, it is possible to work out the building qualities of two different lacquer surfacers and thus compare them.

CHARLES W. FOX:—Can lacquer be applied to castings and forgings? If so, is the priming coat necessary? If it is necessary, will the adhesion be sufficiently great to permit the machining of such parts without any danger of damaging the lacquer?

MR. HOLLEY:—The answer to all three questions is: Yes.

W. S. HOWARD:—To what degree of heat can lacquer finish be subjected that has been previously applied to a wooden article, without injuring the lacquer? To what degree can it be heated before it blisters?

MR. HOLLEY:—We have no trouble after subjecting lacquer films to a temperature of 150 deg. fahr. for a considerably protracted time.

EFFECTS OF SALT AIR ON LACQUER

LEE CARLSON:—What is the effect of salt-water atmosphere on lacquer finish?

MR. HOLLEY:—Of all the finishes of which we know, a properly constructed lacquer system is the most resistant to salt water of any. In fact, some of the leading automobile companies evaluate a lacquer system and a lacquer coating and pass on and approve lacquers largely by the salt-spray test, the same test as it used in testing nickel-plate. But to be thoroughly resistant to salt water, there must be a very definite amount of lacquer on the job. In other words, if a car be finished with two double coats of lacquer and most of that lacquer be cut down in the rubbing and polishing operation so that there is only about one coat left and a very thin coat at that, then the salt will penetrate through that very fine thin film of lacquer down into the undercoats and pass rapidly to the surface of the metal itself, and corrosion will start and start very quickly. If a lacquer finish or a lacquer system is wanted that will be thoroughly resistant and protective against salt water, at least three double coats of lacquer must be applied and they must not be cut down greatly in the rubbing operation. If that be done and the lacquer be a properly balanced one, it will resist salt water very thoroughly whether it be in the North where the temperature is low or in Florida or along the coast of Southern California where the temperature is higher.

MR. HOWARD:—Has the alkaline dust of the West any worse effect than that of salt water on a lacquer surface?

MR. HOLLEY:—I think that the ordinary Western alkali is not particularly harmful, although if alkaline dust is driven at a high velocity by the wind, it will soon cut the coating down to the metal. There have been instances of cars right out of the factory that have been driven out to the West Coast and through sand storms which cut the finish right down to the metal on the side the sand was coming from. Alkaline dust lying on the surface of lacquer is not harmful.

QUESTION:—Can lacquer be applied to a baked-japan surface? If so, what method should be used?

MR. HOLLEY:—To apply a lacquer successfully over a black baked-japan surface, a very thin coat of especially prepared low-pigment lacquer-primer should be applied first to get a proper bond between the lacquer coat and the black baked-japan. If the surface were rubbed slightly with sandpaper and the inspection is good enough to be depended upon, the lacquer primer can be dispensed with and the bonding will be good.

QUESTION:—In reference to reclaiming lacquer from the spray booths is that lacquer a safe one to put on a product or on the market? In the first spray are any of the ingredients of the lacquer lost besides the solvent?

MR. HOLLEY:—That is a difficult question to answer. I can see no objection to cleaning out a spray booth and using the lacquer but that lacquer would not be suitable for first-grade work. One reason is that a number of the lacquers on the market contain vegetable drying oils, the same drying oils as we have always used in the manufacture of varnishes, enamels and automobile undercoatings under the old system. Those vegetable drying oils will pass from the liquid phase into the solid phase through oxidation, and they will do that on the walls of the spray pool. When an attempt is made to dissolve those oils with lacquer finishes, and to apply that lacquer, the balance in the composition of the lacquer has really been destroyed because those vegetable drying oils will not again dry through oxidation. They are merely there, but do not help construct the second film-formation, and I question whether such a lacquer would have the wearing value that it originally had. But there are many places where such a lacquer can be used. I think there would be no trouble in finding enough usage for it around a production shop. It would make a very good coating to put on engines.

ELIMINATION OF POLISHING OPERATION

EUGENE BOUTON:—What information can you give us regarding gloss lacquer to eliminate polishing?

MR. HOLLEY:—There has been a rather earnest effort put forth by every lacquer manufacturer to produce a gloss lacquer comparable to the gloss of a color varnish. Such a gloss can be secured, and sometimes it is, but not in a balanced form of lacquer as yet. I expect that during the coming year, due to certain developments of some of the leading organic chemists in this Country, we will have such a lacquer.

Another feature enters into that besides the mere quality of gloss and that is the mirror effect. Lacquers have a tendency to produce a rather pebbled effect. We have got away from the worst of it, but lacquers do not flow out as smoothly as did our old color varnishes, and I question whether we will ever get mirrorlike effects with gloss finish that we used to have from our color finishes. But, for the rather low-priced or popular-priced cars, I think we will see lacquers of balanced formulation, which means satisfactory wearing qualities and sufficient gloss to avoid rubbing. It is not going to be a matter of entire saving at that, when they do come, because those constituents are going to cost more and we will have to use a higher type of reducer; and, while we can possibly save in labor, the lacquer material will cost somewhat more. The

difference probably will be sufficiently attractive to warrant their adoption.

W. W. VANCE:—As to the sheet metal which is intended for use in fenders, hoods and bodies, should the metal have a smooth finish if it is to be lacquered?

MR. HOLLEY:—Sheet metal for parts such as fenders and dash shields should be smooth if a straight lacquer system is used, that is, metallic finish. Lacquers do not have the filling qualities that other finishes in the past have had; so defects in the metal will be very apparent. On a smooth sheet of metal it is a rather difficult proposition to set up a lacquer system and lacquer foundation that will assure the good comparative wear of such a lacquer system with that of a baked japan-finish. Lacquers are much more sensitive to sudden impacts, like the picking up of a pebble by the tire and its bouncing against a fender, than are baked japans. That has been one of the difficulties in attempting to use lacquer systems as finishes.

We have not yet mastered and obtained the lacquer ingredients which have the specific quality of permanent adhesion to metal as we have mastered that problem in the older type of finishes.

MR. SMITH:—In regard to the difference between the old finishes and the newer system of finish, in all joinings or meetings of the metal, where it is apt to work or rub, the old finish will stand up without chipping.

MR. HOLLEY:—Probably some of those who are engaged in the manufacture of lacquer will dissent from my opinion, but I think that we have not arrived as yet at a satisfactory lacquer primer. If I had the say of what was going on an automobile of my own, I would not use lacquer primers today as we know them. The best foundation I know of for a lacquer top-coating is a force dried or baked oil-primer.

Difficulties Due to Lacquer Shrinkage

E. F. CATHCART:—The chief difference in the lacquer surfacer is the shrinkage due, I presume, to the fact that the solid content dries entirely by the evaporation of the volatile content. Is there anything that will offset that entirely?

MR. HOLLEY:—No, that is one of the things we have to contend with. In an oil surfacer there is about 80 per cent fixed volume, and in a lacquer surfacer there is 35 to 40 per cent fixed volume. Until we can build that volume up to around 60 per cent, which I think is a fair probability during the coming year, we will not overcome that difficulty. But when we have built up that volume, we will have in a large measure overcome the shrinkage. If the lacquer surfacer be applied to a body while it is still warm after it has come out of the oven, there will be less shrinkage of the surfacer on account of the greater speed of evaporation taking place during the formation of the film, but I think the true answer lies in building up the volume content of the surfacer which, in the last analysis, means reducing the viscosity of the nitrocellulose and approximately maintaining the present tensile strength and elasticity.

A. R. HOPKINS:—To facilitate a quick repair in a paint job that has been done with an oil primer, is there any hazard in covering a small surface with a lacquer primer? Will any chemical reaction take place that will cause an off-color or any such condition in the finished surface?

MR. HOLLEY:—Recently, I visited one of the rather large production plants and they were doing exactly that sort of thing and running every sort of color on their finishing line. There was no crowding and no difficulty arising therefrom. It seems to be a thing that is very easily handled.

Development of Clear Lacquers

M. T. PEARCE:—What is the possibility of the development of a clear type of lacquer to serve all practical purposes, the same use that finishing varnishes formerly served? If such a material is developed, is it likely to be as durable as the color lacquers?

MR. HOLLEY:—It seems doubtful if they would be as durable as the pigmented lacquers, that is, the strongly pigmented lacquers. There does seem to be very good grounds for believing that we will be able, say inside of 3 years, to produce a top coating which will have an enamel gloss, not a finishing-varnish gloss, but an enamel gloss, which will carry a very small percentage of pigment, probably equivalent to mixing one part of lacquer enamel with two parts of a clear lacquer, say about 10 per cent of the pigment that is present now in the color line. I think this because there seems to be a pretty definite idea among lacquer chemists as to just about what they want, but the hitch is that they are in the hands of the organic chemists who are working on those things and until they get us those ingredients which we do want and which we know something about at a reasonable price, we will not be able to produce that type of finish.

G. C. GIVEN:—I think most of the trouble is not exactly due to shrinkage. If a lacquer surfacer is dried sufficiently long so that it has taken up all the shrinkage before sanding, the shrinkage is no longer there; but, when the subsequent coat of lacquer is put on top, there is a certain swelling that takes place over the file marks which makes ridges and these ridges never seem to sink back to their original form. Do you think that is true?

MR. HOLLEY:—Yes.

MR. GIVEN:—I do not know how that will be overcome so long as the surfacer remains soluble in the lacquer.

MR. HOLLEY:—I think that condition will continue, but the ingenuity of the production engineer can be utilized to a great extent in overcoming it. In almost any custom shop the workmen have learned one way or another to take care of that shrinkage. That proposition largely will have to be worked out individually according to the requirements of the production line, with the cooperation of the lacquer engineer. We will overcome it to a greater extent when we know something more of lacquer-surfacer formulation, of which we are now only in the early stages of knowledge. When we can build up the total solvents with nitrocellulose of a somewhat different characteristic than the nitrocellulose we have now, that will tend to reduce shrinkage.

Reports of Society Committees

MEETINGS COMMITTEE

Owing to the necessity of making Summer Meeting hotel arrangements at least 6 months in advance, the Meetings Committee, in accordance with the usual custom, recommended after careful study that the 1928 Summer Meeting should be held at Quebec, June 26 to 29. This recommendation has been accepted and approved by the Council.

In deciding upon Quebec, the committee was guided very largely by the vote of the Society membership. A special *Meetings Bulletin* was sent out on Oct. 18, outlining the advantages and disadvantages of Spring Lake, N. J., Atlantic City, an ocean cruise, and Quebec, the only Eastern places considered suitable for holding the Summer Meeting. A Western place was not included inasmuch as the 1926 and 1927 Summer Meetings have been held in French Lick Springs, Ind. A total of 915 votes were cast, decided preference being indicated for the ocean cruise and Quebec. The members voting for Spring Lake and Atlantic City were asked to vote again, limiting their choice to the ocean cruise and Quebec. The revised vote indicated that Quebec was preferred, the final count being 393 in favor of Quebec, as against 332 in favor of the ocean cruise. The votes remaining for Spring Lake and Atlantic City were 73 and 128 respectively.

The Meetings Committee is confident that the Chateau Frontenac at Quebec will be found most satisfactory for the holding of technical sessions and social events. The hotel has over 1200 rooms and baths available. The fact that Quebec is of great historic interest, being the only city in the Western Hemisphere that has a distinct European character, would make the trip to Quebec worthwhile in itself to any members who have not been there.

During the present administrative year the Meetings Committee has held six National meetings and the Annual Dinner. The time, place, attendance, number of sessions held and number of papers presented are given in the accompanying table. The trip to the Aberdeen Proving Ground on Oct. 6 at the invitation of the Army Ordnance Association is not included in the table as no check was made of the number of Society members attending.

Beginning with the Aeronautic Meeting, an attempt has been made to preprint as many of the National meeting papers as possible, sending copies prior to the meeting to members interested in discussing the papers. This service was greatly appreciated at the Aeronautic Meeting.

The technical program for the Annual Meeting has been arranged with the understanding that preprints of papers would be available, authors consequently being limited to 10 min. for the presentation of their papers. The total time taken by a paper is thus dependent on the interest and resulting discussion rather than on the length of the paper.

The success of the Aeronautic, Transportation and Production Meetings was due very largely to the committee chairmen responsible for the technical programs of these meetings.

The Aeronautic Meeting was under the direction of Hon. E. P. Warner, the other members of the committee being E. E. Aldrin, H. M. Crane, E. T. Jones, Alexander Klemin, W. L. LePage, L. D. Seymour, W. B. Stout, and J. A. C. Warner.

F. J. Scarr served as chairman of the Transportation Meeting Committee. The members of his committee were H. C. Crowell, H. L. Debbink, F. I. Hardy, F. C. Horner, R. E. Plimpton, F. G. Whittington, J. F. Winchester, and Edward Wotton.

The Production Meeting was directed by John Younger. The personnel of the committee was practically the same as that of the Production Advisory Committee, the mem-

1927 S.A.E. NATIONAL MEETINGS

Meeting	Date	Place	Registration	Sessions	Number of Papers
Annual	Jan. 25-28	Detroit	826	11	27
Summer	May 25-28	French Lick Springs	745	8	20
Production	Sept. 19-22	Cleveland and Detroit	399	6	14
Aeronautic	Oct. 18-20	New York City	346	4	15
Transportation	Oct. 25-27	Chicago	303	6	22
Tractor	Dec. 1	Chicago	72	1	3

bers being Eugene Bouton, E. P. Blanchard, W. G. Careins, F. H. Colvin, T. B. Fordham, A. R. Fors, Paul Geyser, J. F. Guider, W. W. Norton, Erik Oberg, C. C. Stevens, W. K. Swigert, E. A. Taylor, and L. L. Williams.

L. C. HILL,
Chairman

MEMBERSHIP COMMITTEE

The Membership Committee has been unusually active during the last year, cooperating directly with several of the Sections in their campaigns to increase membership. This has greatly helped to strengthen the Society by increasing National membership through the Sections activities.

As of Dec. 31, 1927, the Society's membership, including Affiliate Representatives, was 6105. This showed an increase of 342 over the figure for the same date of the previous year.

Dropping action for those members who were not sufficiently interested in the Society to pay their dues was taken up promptly at the close of the fiscal year, and by campaigning work it was possible to reduce the number dropped for such reasons to approximately one-half that of previous years.

A comparative membership figure is given in the following table:

	Dec. 31, 1926.	Dec. 31, 1927
Members, including Foreign and Service	3,095	3,284
Associates	1,858	1,960
Juniors	503	560
Affiliates	110	110
Affiliate Member Representatives	197	191
	5,763	6,105
Enrolled Students	221	355
	5,984	6,460

Applications received during the year totaled 929 against 881 for the previous year and the percentage of those qualifying was 70 per cent against 88 per cent for 1926.

The Membership Committee wishes to express its sincere appreciation to the members who assisted in aiding this growth of the Society. The Section Membership Committees are also to be complimented on their active interest in the work.

F. K. GLYNN,
Chairman.

OPERATION AND MAINTENANCE COMMITTEE

The Operation and Maintenance Committee of the Society is a semi-administrative body that was organized in 1926 to carry on the general work of the Society in the interest of members and others whose work is in the motor-vehicle fleet-operating field. In 1927 the Committee was organized in a broader way, the members being selected from the West Coast, the Rocky Mountain, the Central, and the East Coast sections of the Country in order to have good geographical distribution and also to represent the various major types of vehicle operation. The Committee was divided into the following Subcommittees, each to study the field conditions coming within its scope and to make recommendations as to what the Society could accomplish in each field:

Subcommittee on Accounting, to study systems of operating-expense determination and economic fleet-transportation management.

Subcommittee on Motor-Vehicle Regulation, to study particularly the technical features of various State and other Governmental vehicle regulations and their relation to fleet operation.

Subcommittee on Nomenclature, to make recommendations as to standard definitions of terms used in connection with vehicle operation and maintenance work.

Subcommittee on Mechanical-Information Sheets, to recommend a uniform style and scope of replacement and repair-parts information-sheets that are furnished by vehicle manufacturers to fleet operators.

Subcommittee on Education, to spread information regarding the Operation and Maintenance Committee and its work, to secure the cooperation of fleet operators in general and to foster the development of operation and maintenance activities in the Sections of the Society.

West Coast Subcommittee, to carry on all the activities of the Operation and Maintenance Committee on the West Coast and adjacent territory.

The Operation and Maintenance Committee has also had cooperating members on the Society's Research, Sections, Meetings, Membership and Publications Committees, as well as members who serve also on the Divisions of the Standards Committee.

The Subcommittee on Accounting was particularly active during the year, its work culminating in the report presented at the National Transportation Meeting of the Society in Chicago last October. This and the reports of the other Subcommittees are printed in the December, 1927, issue of THE JOURNAL, commencing on p. 644. E. C. Wood, vice-chairman of the Operation and Maintenance Committee and chairman of the West Coast Subcommittee, also presented exhaustive reports on fleet operation and maintenance conditions and practices on the West Coast, which were printed in THE JOURNAL of January, 1928.

At the National Transportation Meeting in Chicago, the advisability of undertaking a broader and more scientific investigation of economic motor-vehicle transportation on a National basis in cooperation with other National bodies was discussed at two conferences of transportation representatives. This study, if undertaken, would be largely the continuation of the work started by the Subcommittee on Accounting but to which it cannot devote the necessary time and work on a larger scale. Such a program will undoubtedly bear also on the work of the Operation and Maintenance Committee as a whole. The possibility of such an enlarged project will be worked out by the Committee in more detail and a program decided upon.

R. E. PLIMPTON,
Chairman

PRODUCTION ADVISORY COMMITTEE

The organizing of the Production Advisory Committee late in 1926 was brought about largely by opinions expressed for some time past by members of the Society interested more in production work than design engineering, that the Society's activities relating to production matters should be broadened and energized.

Considerable interest has been shown in the greater development and use of standardization in connection with machine and small tools, jigs, fixtures and other manufacturing equipment as well as methods, processes, and materials. The greatest difficulty in this work, however, has been to secure the active participation of the production engineers in programs that had been outlined for the Committee. This has probably been largely because the production engineers as a whole have not hitherto constituted a very large group of the Society's active members and they have not had the advantage of experience in meetings and Committee activities. It is realized that, under present manufacturing practices, the production engineer finds himself much more restricted than the designing engineer in taking time away from his office to attend meetings and otherwise take part in such work. Probably some of the difficulty has also been lack of understanding and appreciation by plant manage-

ments of the purpose of these activities and the benefits to be derived from them, especially by those who participate directly in this work.

Three meetings of the Committee were called during the year to consider ways in which the program that was formulated could be expedited but progress has not been sufficient to present any more definite reports at this time.

The first regular S.A.E. Production Engineering Standards were adopted by the Society in 1927. The Production Advisory Committee in cooperation with the Production Division of the Standards Committee considered several forms in which to publish and distribute them and decided that each standard should be printed in a separate pamphlet 8½x11 in. in size and punched for filing in standard three-ring binders. When a sufficient number of production engineering standards have been adopted to make it possible to combine two or more closely related ones in a single pamphlet, the Committee will be asked to consider the advisability of doing so.

The Committee cooperated in preparing the program for the Society's National Production Meeting that was held in Cleveland and Detroit last September. The members of the Committee were also delegated during the year to cooperate with the Society's Research, Meetings, Sections, Publications and Membership Committees in their programs. The members of the Committee have also cooperated with the Production Division of the Standards Committee.

In order to centralize items in the S.A.E. Journal that are of particular interest to production engineers, a Production Engineering Section has been included in each issue, commencing with that of May, 1927. This Section will be continued in future issues inasmuch as it has been generally approved by the production members.

It is hoped, in continuing the production activities within the Society, that this group of members will take greater interest in the work and cooperate even more actively in order to make the Society and the mediums through which it works of the greatest possible use to them. An essential factor in developing this whole program is endorsement of it by the manufacturing executives and more general appreciation of the increasing benefits that will accrue to their companies and engineers as the work develops and its results impress themselves upon manufacturing practices.

EUGENE BOUTON,
Chairman.

PUBLICATION COMMITTEE

Increases in the total number of pages, the number and percentage of text pages and the number of National meetings papers published in THE JOURNAL characterize the publication activities of the Society for the year 1927, as compared with 1926. Fewer Sections meetings papers and contributed articles were published, and the number of discussions published after the papers to which they belong were printed also decreased. This last is due to the efforts that are being made to print papers and their discussions, as far as possible, in the same issue of THE JOURNAL. The remarkable success already attained in those endeavors has been made possible by a reorganization of the Publication Department at the offices of the Society, which included the securing of additional personnel, and by the really exceptional efficiency and speed with which the members of the Publications staff have worked, especially at the times of National meetings. Table 1 presents comparative data on the size of and the material included in THE JOURNAL for the last 2 years, and Table 2 shows how promptly after presentation papers and discussions were published in 1926 and 1927.

TABLE 1—COMPARATIVE DATA ON SIZE OF AND MATERIAL INCLUDED IN THE JOURNAL FOR 1926 AND 1927

	1926	1927
Total Pages	3,012	3,240
Text Pages	1,457½	1,679
Percentages of Text Pages	48.4	51.9
National Meetings Papers Published	75	91
Sections Meetings Papers Published	55	47
Discussions Published Separately	35	26
Contributed Articles Published	5	4

The standards of the Publication Department regarding care and thoroughness in editing the material published each month, already high, have been maintained and efforts are constantly being made to improve in this respect and also in the attractive appearance of the pages of THE JOURNAL. A number of changes in the makeup and arrangement have been made and others are receiving consideration.

Part II of the 1925 TRANSACTIONS, which contained 43 papers and consisted of 928 pp., was mailed to the members the latter part of June and Part I of the 1926 TRANSACTIONS, containing 26 papers and consisting of 688 pp. was sent out recently. Work on Part II of the 1926 TRANSACTIONS has been begun, and this Part should, barring any unforeseen delays, be mailed prior to the Summer Meeting. The Publication Committee is now considering the list of papers to be included in Part I of the 1927 TRANSACTIONS.

In determining whether or not a paper or a contributed article that has been published in THE JOURNAL is to be reprinted in TRANSACTIONS its value as at least semi-permanent reference material receives careful consideration. Some material, while possessing great current interest at the time of its publication in THE JOURNAL, fails to meet this requirement and is therefore excluded from TRANSAC-

TABLE 2—TIME ELAPSING BETWEEN PRESENTATION AND PUBLICATION OF PAPERS AND DISCUSSIONS

	Papers Printed				Discussions	
	Without Discussion		With Discussion		Printed Separately	
	1926	1927	1926	1927	1926	1927
Total	91	80	39	58	35	26
First Issue after Presentation	54	36	0	0	0	0
Months Later						
1	10	10	0	3	0	0
2	8	13	1	9	0	5
3	3	2	6	5	3	1
4	6	3	5	5	3	4
5	8	3	17	5	4	1
6	0	4	6	1	13	3
7	0	3	1	15	1	4
8	0	2	0	8	6	2
9	0	2	1	2	3	3
10	0	2	0	0	2	3
11	1	0	1	5	0	0
12	1	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	1	0	0	0

TABLE 3—PERCENTAGE OF PAPERS THAT HAVE BEEN REPRINTED IN TRANSACTIONS

		1924	1925	1926
Total Papers Published in THE JOURNAL		34.00	54.05	55.81
Papers Presented at National Meetings		35.51	47.87	51.25
Sections Meetings Papers Published in THE JOURNAL		41.03	51.35	56.36
	1923	1924	1925	1926
Papers Published				
Journal	86	150	111	129
Transactions	56	51	63	72
Per Cent	65.12	34.00	54.05	55.81
National Meetings Papers				
Presented at Meeting	62	98	94	80
Published in Transactions	34	35	45	41
Per Cent	54.84	35.51	47.87	51.25
Sections Meetings Papers Published				
Journal	35	39	37	55
Transactions	23	16	19	31
Per Cent	65.71	41.03	51.35	56.36

TIONS. Table 3 gives the percentage of total papers published in THE JOURNAL for the last 4 years which have been reprinted in TRANSACTIONS, together with the same information regarding the papers presented at National meetings of the Society and Sections meetings papers published in THE JOURNAL.

EDWARD P. WARNER,
Chairman.

RESEARCH COMMITTEE

The Research Committee, in addition to its specific duties, brings together a number of those who are applying science to the progress of the automotive industry; for exchange of ideas and experiences, and more particularly to foresee insofar as possible further technical needs of the industry and encourage research projects to meet these needs. The results of these contacts are made available to the Society as a whole through the Automotive Research department of THE JOURNAL, through papers presented at the Society meetings, and through the work of the Research Department. The Research Committee is also called upon to give its opinion as to what research projects proposed should receive the endorsement of the Society, and to exercise supervision over the investigations sponsored and over the work of the Research Department. The topics to which the Committee and its Subcommittees have devoted definite attention during the past year are fuels, headlighting, highways and riding qualities.

FUEL RESEARCH

The underlying object of the cooperative fuel-research is to supply technical data needed by both the industries concerned to maintain the best adaptation of the fuel and the engine to each other in the interest of National efficiency. Incidentally, it has resulted also in increased cooperation between the two industries and in the establishing of a number of research laboratories dealing with motor fuels.

In the past the program has dealt with the effect of volatility on over-all fuel consumption and on crankcase oil dilution and with the effect of the lower range of the volatility curve on engine starting. A paper by D. C. Ritchie at the Summer Meeting on the relative starting characteristics of cracked and straight-run gasolines practically concludes the work on starting.

The major problems of the current year have been to determine factors affecting acceleration of the engine, particularly the effect of the intermediate range of fuel volatility, and to secure further information on the knock ratings of fuels on the market and on the various proposed methods of rating fuels with regard to their knock characteristics. The paper by J. O. Eisinger at the summer meeting, entitled Engine Acceleration Tests, will be supplemented by a paper by Donald Brooks at the 1928 Annual Meeting.

Another phase of the subject is the correlation of the A.S.T.M. distillation curve with volatility measurements made under conditions more nearly approximating those prevailing in an engine manifold.

Dr. C. S. Cragoe and J. O. Eisinger in the paper presented at the Annual Meeting of the Society established a correlation between two points on the A.S.T.M. distillation curve and the volatility requirements for engine starting. The prospects for obtaining such a correlation over the whole range of gasoline volatility appears very promising, and the accomplishments in this field since the report presented at the 1927 Annual Meeting are embodied in a paper by O. C. Bridgeman for presentation at the present Annual Meeting. Further activity in this general division will include testing the latest Deppé end-point apparatus, the measuring of volatility and dew-points of a wider range of fuels than has hitherto been used, and the study of the Sligh equilibrium air and bomb-test apparatus.

Two surveys of the detonation characteristics of motor fuels have been made, the first of gasoline as produced by refineries; the second, of the fuels as sold to motorists in various parts of the Country. H. K. Cummings is reporting on this phase of the research in a paper at this Annual Meeting.

The contact with methods of measuring detonation characteristics now in use has been maintained over the past year, and the results of this observation are embodied also in the paper by Mr. Cummings, which will in this respect supplement his report presented at the 1927 Annual Meeting. Through its representation on the Cooperative Fuel-Research Steering-Committee, the Research Committee has also been fortunate enough to be apprised of two other studies of detonation measurement, one by Dr. Graham Edgar and one by Neil MacCoull, both of which are the subjects of papers for this Annual Meeting.

Future detonation research will include a second survey of the detonation characteristics of fuels available to the motorist; the continued observation of methods of measuring detonation, both by comparative laboratory tests, already initiated, and the collection of printed information.

HEADLIGHTING

About a year ago a headlight research project was authorized to be carried out at the Bureau of Standards under the technical direction of the Research Committee and under the direct supervision of its Chairman. Efforts to determine what lighting patterns are best suited to furnish drivers with adequate illumination under the varying conditions of road, atmosphere and opposing lighting have been actively pushed. A report in the Automotive Research section of the October Journal briefly summarizes the observations so far made of the distances at which a given object becomes visible to a driver, both with and without opposing lights, under various conditions. When a sufficient number of tests have been made the data will be analyzed statistically. H. H. Allen, who has performed the experimental work, is scheduled for a progress report on this subject at this Annual Meeting.

A second line of endeavor thought helpful was to enlist the active interest of car manufacturers in the subject of providing adequate illumination for night-driving. In a joint project with the Illuminating Engineering Society, a headlight test apparatus that can be easily manipulated to furnish a large variety of light patterns was developed and distributed at the cost price to interested manufacturers. The original thought was that, through experiment with this apparatus, manufacturers could determine what seemed to them the ideal light distribution. At an informal meeting held on Nov. 15, representatives of the Headlight Subcommittee of this Society recommended that the nature of this project should be changed from experimental to educational, experience having indicated that

this alteration in view was advisable. This suggestion will be submitted to the joint committee of this Society and the Illuminating Engineering Society for action.

While engaged in studies looking toward the providing of adequate and satisfactory lighting, the Research Committee was called upon to deal with a current urgent situation. At its November, 1925, meeting, the Council had taken action restraining the Lighting Division of the Standards Committee from changing the S.A.E. Recommended Practice on head-lamp illumination pending the headlighting studies of the Research Committee. A need arose for some immediate revision of these specifications and specifically a specification for dual-beam equipment. A joint meeting of the Standards and the Research Committees called to consider these circumstances recommended that the Council direct the Lighting Division to prepare a specification for 21-21 cp. incandescent electric lamps, and a suitable specification for head-lamp illumination when using the 21-21 cp. dual-beam lamps, and to take certain other steps to meet the requirements of the situation. At its recent meeting the Council approved these recommendations.

Highways

In the field of highway research, the activity of the Research Committee has centered mainly on the cooperative study of motor-truck impacts, carried out by the Rubber Association of America, the Bureau of Public Roads and this Society. The motor-truck impact-tests have been continued to include cushion and solid tires cut to various thicknesses to simulate tires worn down in service.

Average impact values were obtained for hollow-center cushion tires, and for high-profile and for regular solid tires cut down to various heights of visible rubber. The runs on which these values were based were made on an artificially obstructed road, at various speeds and loads.

A second portion of the test program was concerned with the effort to determine experimentally and to show graphically the interrelationship of the four major variables—road roughness, tire equipment, wheel load and vehicle speed—on the magnitude of impact reactions.

Concurrently with the major research, efforts have been bent toward developing a method for correlating static and dynamic tire-tests. A subcommittee was appointed early in the year to consider this question, and the Society's representatives, from the results of static tests made by other members of the Subcommittee and similar experiments which they carried out at the laboratory of Cooper Union, together with data on impact tests furnished by the Bureau of Public Roads, formulated a statistical method of study which has been submitted to the committee as a whole and approved by it for further trial.

This Society also participates in highway research through representation on the Highway Research Board of the National Research Council.

Riding-Qualities

In the field of riding-qualities, the Research Committee has functioned not as a directing agent, but as a medium of exchange of information on investigations being made by its own members and others; and has stimulated the presentation of such material to members of the Society. Through promotion by the Research Department, one such research project is being carried out under the general supervision of Prof. E. H. Lockwood, at Yale University, where a vibrating chair, which will be later used to test the susceptibility of persons to vibrations of various periods and amplitudes, is being designed. Two studies on accelerometers were reported in the Automotive Research section of the August issue of The Journal, one further analyzing a previously presented formula for the gap error in the contact-type accelerometer; the other, describing the design and testing of an accelerometer calibrating apparatus. An informal circular has been prepared by the Bureau of Standards to meet the many inquiries concerning the accelerometer designed by that Bureau, and is available to the public. The investigation being carried out by the Firestone Tire & Rubber Co. on the possibilities of high-speed photography in analyzing the movements that occur in tires when they are passing over obstructions, and the measurement of riding-qualities with a six-element contact-type accelerometer, constitute the subject matter of a 1928 Annual Meeting paper by R. W. Brown.

A subject somewhat allied to riding-qualities, on which the Research Committee was called upon to act, is the proposed cooperation with the Special A.S.M.E. Research Committee on Mechanical Springs. This committee proposes to cover all phases of investigating the design and manufacture of functional springs, which include all springs in a car except those of the suspension type, also the design and manufacture of individual suspension springs. It desired the Society to cooperate by appointing a member to partake in its deliberations and to represent the interests of both societies, by giving information as to the research problems encountered in the automotive industry, and to assist in the soliciting of funds from the automotive industry. The Chairman of the Research Committee has provided for representation on the Special A.S.M.E. Research Committee on Springs, so that the Society may be kept in touch with the progress of the work and the nature of cooperation desired from the Society.

H. C. Dickinson,
Chairman

SECTIONS COMMITTEE

During the present administrative year the relation between the local Sections and the Society office has been studied, certain changes having been made and machinery set up so that the Sections officers and committees would receive the maximum amount of assistance from the Society office.

In this connection the National Membership Committee is contacting with the Section Membership Committees in an effort to increase National and Section membership through Section activity, special campaigns having been undertaken for the Chicago, Cleveland and Detroit Sections. General information regarding this work has been broadcast to all Sections.

One problem that has been put on a standardized workable basis is the Section mailing lists. At the first of each fiscal year a complete card index of Society members in the Section territory is furnished each Section. New cards are issued each week covering changes in address, new members, and resignations, so that the list may be kept permanently uptodate.

Since the last report of the Sections Committee, members in St. Louis, Seattle, Flint, and Pontiac are considering the possibility of forming Sections. The students at the General Motors Institute of Technology have organized a Student Group, the Council having approved the Constitution in November.

Secretary Clarkson, on his trip to the Aeronautic Meeting at Spokane, attended a meeting of Washington members interested in organizing a Society group in Seattle. While on the West Coast he also attended meetings of the Northern and Southern California Sections. His presence was greatly appreciated. It is urged that Society members going to the West Coast notify the Society office so that the Californian Sections may be advised and have the opportunity of inviting such members to attend their meetings.

This year the Detroit Section, under the able guidance of Walter Fishleigh, has been holding extraordinarily successful meetings, one meeting being attended by over 700 members and guests. This activity in Detroit, the center of the automotive industry, is most welcome to the Sections Committee. At the present time the geographical center of membership is half-way between New York City and Detroit. With an active Detroit Section and addi-

CHAIRMEN OF COMMITTEES MAKING REPORTS AT THE ANNUAL MEETING AND THE TREASURER

MEMBERSHIP AND FINANCES OF THE SECTIONS OF THE SOCIETY, OCT. 1, 1926, TO OCT. 1, 1927

Section	Section Membership, Oct. 1, 1927	Percentage of Section to Society Members	Section Dues	Section Appropriations	Section Appropriation per Member	Total Section Expenses[1]	Expense per Member	Section Papers Published in Journal
Metropolitan	833	80	$4,050.00	....	....	$5,041.23	$6.05	5
Detroit	807	83	3,955.00	$1,000.00	$1.24	4,896.24	6.07	8
Chicago	303	75	1,467.00	....	....	1,468.75	4.85	1
Cleveland	277	75	1,332.50	250.00	0.90	1,583.97	5.72	0
Pennsylvania	224	98	1,577.00	....	....	1,797.76	8.02	2
New England	129	106	624.00	376.18	2.92	819.32	6.35	1
Buffalo	114	135	545.00	400.00	3.51	1,044.86	9.17	4
Indiana	114	106	555.00	620.00	5.44	999.12	8.76	3
Milwaukee	98	78	482.50	500.00	5.10	1,029.45	10.50	2
S. California	93	77	457.50	175.00	1.88	622.50	6.69	2
N. California	88	65	420.00	350.00	3.98	624.68	7.10	4
Washington	65	64	277.50	....	....	705.96	10.86	1
Dayton	64	43	325.00	....	....	506.69	7.92	1

[1] Section income from dinners deducted.

tional Sections in nearby cities, the membership in these centers will naturally increase and the Society geographical center will be brought nearer to Detroit.

More interest in Section activities is being shown by the members in practically all 13 Sections, if the figures for paid-up Section dues are any criterion. The number of Section dues collected on Dec. 31, 1927, were 312 ahead of the number for the same time the year before.

In order that the Sections might be put on a more comparable basis, the accompanying table covering membership, dues, appropriations, and expenses has been compiled.

F. F. CHANDLER,
Chairman.

STANDARDS COMMITTEE

The Society's Standards Committee has made substantial progress during the year 1927, notwithstanding the increasing complexities attending standardization activities that have developed in practically all lines of industry. Trade organizations, engineering societies and other groups and individual companies previously not actively interested in standardization have become interested, with the result that more cross-currents have developed in the regularly organized procedure. The automotive industry in particular has been moving more rapidly than ever and the highly competitive conditions of today have resulted in increased difficulty of finding qualified men in the industries who were willing or able to give this valuable work the necessary time and thought toward accomplishing the best results in the shortest time and at least cost. More of the work has been done by correspondence through the Society's Standards Department and it has been necessary in many cases to resort to telegraphing and long-distance telephoning to accomplish the desired progress.

ORGANIZATION

The policy of rearranging and in some cases consolidating Divisions of the Standards Committee in order to improve organization and functioning has been continued. The Chain Division was discontinued inasmuch as its activities heretofore related mostly to the roller type of chain which is used to a very limited extent in motor vehicles. Large quantities of these chains are used, however, in other mechanical industries and standardization is being carried forward by a Sectional Committee of which the Society is one of the sponsors under the procedure of the American Engineering Standards Committee. The work of the Passenger-Car-Body Division was consolidated with the Passenger-Car Division, as was also that of the Storage-Battery Division with the Electrical Equipment Division. The Standards Committee is comprised of 22 Divisions, the smallest (Motorcycle) having 3 members and the largest (Iron and Steel), 22 members. The total members of all Divisions of the Standards Committee is 247, an average slightly more than twelve per Division.

As in 1926, the Special Committees on Standardization Policy, Methods of Expressing Limits and Tolerances, and on Patents were continued to advise with the Divisions of the Standards Committee as occasion required. Although there has been relatively little for these Committees to do, the Policy Committee reported the following general outline of policy as to the Society's standardizing activities.

> The purpose of the Standardization Policy Committee is to define the general Policy of the Society's standardization activities and to act in an advisory capacity with the Divisions of the Standards Committee on subjects involving questions of policy.
>
> Specifications may be standardized to
>
> (1) Promote interchangeability of parts and units
> (2) Eliminate unnecessary variety of parts and materials
> (3) Facilitate production and maintenance
> (4) Promote uniform methods of testing
> (5) Establish nomenclature and standardize tests of performance or operation
> (6) Set up standards or codes for promotion of safety.
>
> Standardization of specifications shall not place unnecessary limitations or restrictions on individuality of design, construction, performance or operation.
>
> Specifications shall not be standardized unless there is sufficient desire for such standards expressed by the industries affected.
>
> The fact that patents or protective rights may relate to a device, material or process does not preclude setting up specifications for such subjects. Where a patent right is known to be involved in standardizing a specification, the subject should be referred to the Patents Committee for consideration and recommendation as to procedure.

No cooperating Committees were appointed during the year as all subjects considered jointly with other organizations have been taken care of by existing Divisions or Committees.

During the year the Standards and Special Committees, among other Committees of the Society, have lost active and valuable members of long standing and exceptional qualifications in the passing of Charles M. Manly and Charles L. Sheppy.

MEETINGS

In the course of the year's activity of the Standards Committee, meetings have been held by the following Divisions and Subdivisions to act on reports, of which some were submitted at the Summer Meeting in May, some are being acted

upon at this Annual Meeting, and some are in progress for report later on.

Division Meetings	*Subdivision Meetings*
Ball and Roller Bearings	Body Lighting-Switches
Electrical Equipment	Bumpers
Engine	Carbureters
Iron and Steel	Engine-Testing Forms
Isolated Electric-Lighting Plant	Head-Lamp Lenses
Lighting	High-Manganese High-Sulphur Steel
Lubricants	Multiple Signal-Lamp Connectors
Motorcoach	Metric Thrust Ball-Bearings
Parts and Fittings	Motorcoach Storage-Batteries
Production	Paints, Varnishes and Enamels
Screw-Threads	Passenger-Car Bumpers
Tire and Rim	Phosphorus and Sulphur Content (Steel)
	Physical-Property Charts (Steel)
	Rivets
	Steering-Gear Connecting-Rods
	Storage-Battery Terminals

Reports

At the Summer Meeting of the Standards Committee last May, six Divisions submitted 20 reports, of which six related to new subjects, ten were revisions, two were cancellations and two were Sectional-Committee Reports for approval by the Society as a sponsor. One of the latter was also adopted as an S.A.E. Standard. At the Standards Committee Meeting this week, 10 Divisions will submit 23 reports, of which 7 treat new subjects, 15 are revisions, and 1 is a cancellation. All of the reports submitted for adoption by the Society last May were approved and published. Those approved at the Annual Meeting this week will be duly submitted to final letter-ballot of the Society members for final adoption, and if so adopted, published.

The first regular Production Engineering Standards adopted by the Society have been published in separate pamphlet form on bond paper trimmed 8½ x 11 in., punched for standard three-ring binders. Copies have been sent to the entire membership of the Society. These reports are on Taps for Cut and Ground Threads in the National Coarse and National Fine Series, Sizes No. 0 to 1½ in.; and on T-Slots, Bolts, Nuts, Tongues and Cutters. Other reports relating to tools are in progress.

S.A.E. Handbook

The S.A.E. HANDBOOK that was issued in March, 1927, was the third issue in bound form and the first to carry the classified list of manufacturers of automotive parts and materials. This list was revised and added to in the September issue and a limited index-tabbing was tried out. This proved popular enough to extend it in future issues of the S.A.E. HANDBOOK.

The Council at a recent meeting authorized restricting the publication of the Handbook to one issue per year, as a matter of economy and also largely because of the relatively few changes that are made from one issue to the next on the semi-annual basis. Commencing with the 1928 issue, the S.A.E. HANDBOOK will be published once a year about the latter part of March. Revisions and new standards approved at the Semi-Annual Meetings will be issued in July or August in pamphlet form, the pages of which will correspond in size and style to the pages of the S.A.E. HANDBOOK. For convenience in referring to these interim reports, the pamphlets will probably be gummed so that they can be inserted permanently in the current issue of the Handbook. These pamphlets will, of course, be incorporated in each succeeding issue of the S.A.E. HANDBOOK.

Standards Surveys

A system of surveying the extent to which S.A.E. Standards are used, and of determining whether they require revision and whether they meet the requirements of existing conditions, has been inaugurated and proved its worth. This system will eventually be extended to cover all of the standards published, but has been applied so far mostly in cases that required such a survey in connection with work in progress. When the system becomes more fully operative, surveys will be made at regular intervals for each standard, and more frequently for the more important standards. The subjects surveyed so far this year are

Cable, Conduit and Tubing Clips
Car Frame-Numbers
Car-Performance Tests
Carbureter Flanges
Engine Numbers
Felt Specifications
Flywheels and Flywheel Housings
Gearshift Positions
Head-Lamp Lenses
Head-Lamp Mounting
Fuel and Lubrication Tube-Fittings
Motor-Truck Bodies
Motor-Truck Cabs
Pneumatic-Tire Rims
Rubber Bushings
Starting-Motor Cable
Tire-Pump Mounting
Plate Glass

Sectional Committees

The Society during the year was a sponsor for the following Committees organized under the procedure of the American Engineering Standards Committee:

Aeronautical Safety-Code
Ball Bearings
Bolt, Nut and Rivet Proportions
Motor-Vehicle Lighting Specifications
Numbering of Steel
Pins and Washers
Screw-Threads
Small Tools and Machine-Tool Elements
Transmission Chains and Sprockets
Wire and Sheet-Metal Gages

The Society was also represented on the following Sectional Committees, but not as a sponsor:

Automobile Brakes and Brake Testing
Code on Colors for Traffic Signals
Drawings and Drafting-Room Practice
Gears
Insulated Wire and Cables
Machine-Tool Safety Code
Pipe-Threads
Plain Limit-Gages for General Engineering Work
Scientific and Engineering Symbols and Abbreviations
Standardization of Shafting (Subcommittee No. 5 on Woodruff Keys)
Use, Care and Protection of Abrasive Wheels
Zinc Coating of Iron and Steel

At the Annual Meeting last January, the Society acted on the Sectional Committee Reports on Small Rivets; Tinners', Coopers' and Belt Rivets; T-Slots, Bolts, Nuts, Tongues and Cutters; Round, Unslotted-Head Bolts; Set-Screw Heads and Jam Nuts; Wrench-Head Bolts and Nuts. Since then the Society has also acted on reports on Numbering of Steels; Small Rivets and Round Unslotted-Head Bolts.

American Engineering Standards Committee

The Society has continued its activities during the year as a member-body of the American Engineering Standards Committee, on which the Society has three representatives and three alternates. The principal development of impor-

tance has been the work of an enlarged A.E.S.C. Rules Committee that has reported a new set of rules for procedure under the A.E.S.C. to meet needed changes brought about by new developments in and extension of a National standardizing program. The S.A.E. Council, at its meeting on Jan. 12, signified its endorsement of a favorable vote by the S.A.E. representatives on the approval of the new rules of procedure.

International Standardization

The only subject that is being considered for international standardization, in which the Society is actively participating, is ball bearings. Negotiations with the European countries have continued throughout the year looking toward agreement on sizes and tolerances; but progress is necessarily slow. The most recent major development was the holding of an international conference on Ball-Bearing Standardization at Stockholm, Sweden, last October. The American Sectional Committee through which this work is being done was not represented at the conference but submitted its views in writing to the foreign delegates thereto.

General Interests

During the past year the Society has been represented on Committees of about 25 other organizations, such as National Societies, Councils, Committees and Government Commissions and Committees that are engaged in standardizing or related programs. Some of these projects have been practically finished, while others are of such a nature as to require continuation into the new year.

K. L. Herrmann,
Chairman.

TREASURER'S REPORT

The financial position of the Society is the strongest since its inception. The budget for 1928 is based on best estimates for safe and conservative administration. All accounts are balanced; unnecessary items are eliminated; inventories are

REPORT FOR FISCAL YEAR ENDED SEPT. 30, 1927

	1927	1926	Increase
Budget Income	$378,400.00	$330,500.00	$47,900.00
Actual Income	379,693.78	360,638.15	19,055.63
Budget Expense	365,900.00	330,500.00	35,400.00
Actual Expense	348,221.28	338,523.26	9,698.02
Unexpended Income	31,472.50	22,114.89	9,357.61
Assets over Liabilities	206,421.52	174,731.15	31,690.37
Securities on Deposit with Chemical National Bank Sept. 30—Par Value	184,000.00	145,750.00	38,250.00
Book Value	178,912.38	139,123.57	39,788.81

BUDGET COMPARISON

Income	Budget 12 Months	3 Months Ended Dec. 31 Budget	Income and Expense	Over Budget	Under Budget
Dues and Subscriptions	$87,000.00	$21,750.00	$20,930.00		$820.00
Affiliated Appropriations	7,500.00	1,875.00	1,875.00		
Interest	10,000.00	2,500.00	2,384.29		115.71
Initiation Fees	17,500.00	4,375.00	4,485.00	$110.00	
Advertising Sales—Journal	225,000.00	56,250.00	56,384.00	134.00	
Advertising Sales—Handbook	18,000.00	4,500.00			4,500.00
Miscellaneous Sales	16,000.00	4,000.00	3,343.90		656.10
Profit from Sales of Securities			814.00	814.00	
Total Income	$381,000.00	$95,250.00	$90,216.19		$5,033.81
Expenses					
Publications	$93,750.00	$23,437.50	$21,740.87		$1,696.63
Sections	11,200.00	2,800.00	3,355.54	$555.54	
Research	19,500.00	4,875.00	3,928.45		946.55
Employment Service	4,000.00	1,000.00	855.04		144.96
Standards	25,050.00	6,262.50	6,150.07		112.43
Meetings—Net Cost[1]	24,600.00	6,150.00	9,352.98	3,202.98	
Cost of Membership Increase	13,600.00	3,400.00	3,974.94	574.94	
Cost of Advertising Sales—Journal	69,050.00	17,262.50	15,475.38		1,787.12
Cost of Advertising Sales—Handbook	3,500.00	875.00	31.48		843.52
Cost of Miscellaneous Sales	10,500.00	2,625.00	1,731.49		893.51
S.A.E. Operation and Maintenance Committee	750.00	187.50	150.79		36.71
S.A.E. Production Committee	750.00	187.50	.34		187.16
General Expense	96,050.00	24,012.50	25,259.55	1,247.05	
Total Expense	$372,300.00	$93,075.00	$92,006.92		$1,068.08
Net Unexpended Income	$8,700.00	$2,175.00	$1,790.73[a]		$3,965.73

	Gross	Cost	Net Income	Cost to Income, Per Cent	Cost to Budget, Per Cent
Initiation Fees	$4,485.00	$3,974.94	510.06	89	78
Advertising Sales—Journal	56,384.00	15,475.38	40,908.62	27	31
Advertising Sales—Handbook		31.48			19
Miscellaneous Sales	3,343.90	1,731.49	1,612.41	52	66

[1] Ticket sales deducted.
[a] Net loss.

COMPARATIVE BALANCE SHEET AS OF DEC. 31, 1927, AND DEC. 31, 1926

Assets	1927	1926	Increase	Decrease
Cash	$41,627.73	$39,417.47	$2,210.26	
Accounts Receivable	27,242.41	24,416.24	2,826.17	
Securities	202,016.38	185,279.82	16,736.56	
Accrued Interest on Securities	2,139.16	2,422.16		$283.00
Inventories	1,250.15	1,129.25	120.90	
Furniture and Fixtures	2,218.15	2,877.03		658.88
Items Paid in Advance Charges Deferred	7,209.10	6,423.09	786.01	
TOTAL ASSETS	$283,703.08	$261,965.06	$21,738.02	
Liabilities				
Accounts Payable	$3,138.90	$1,710.00	$1,428.90	
Dues and Miscellaneous Items Received in Advance	65,551.35	63,388.81	2,162.54	
Reserves Set Aside for Anticipated Expenses	10,382.04	12,580.32		$2,198.28
General Reserve	206,421.52	174,801.15	31,620.37	
Net Unexpended Income	1,790.73[b]	9,484.78		11,275.51
TOTAL LIABILITIES AND RESERVES	$283,703.08	$261,963.06	$21,738.02	

INCOME AND EXPENSE COMPARISON

		3 Months Ended Dec. 31			
Income	December	1927	1926	Increase	Decrease
Dues and Subscriptions	$7,096.75	$20,930.00	$20,128.50	$801.50	
Affiliated Appropriations	625.00	1,875.00	1,875.00		
Interest	901.89	2,384.29	2,160.67	223.62	
Initiation Fees	1,245.00	4,485.00	6,055.00		$1,570.00
Advertising Sales—JOURNAL	18,078.00	56,384.00	55,323.00	1,061.00	
Advertising Sales—HANDBOOK					
Miscellaneous Sales	1,207.59	3,343.90	6,239.71		2,895.81
Profit from Sales of Securities		814.00		814.00	
TOTAL INCOME	$29,154.23	$90,216.19	$91,781.88		$1,565.69
Expense					
Publications	$6,848.41	$21,740.87	$17,742.44	$3,998.43	
Sections	1,232.51	3,355.54	3,400.80		$45.26
Research	1,275.65	3,928.45	3,587.81	340.64	
Employment Service	293.91	855.04	855.59		.55
Standards	2,360.39	6,150.07	5,046.46	1,105.61	
Meetings—Net Cost[a]	1,317.76	9,352.98	7,143.52	2,209.46	
Cost of Membership Increase	1,623.84	3,974.94	2,766.50	1,208.44	
Cost of Advertising Sales—JOURNAL	5,033.43	15,475.38	14,614.22	861.16	
Cost of Advertising Sales—HANDBOOK	18.98	31.48	.35	31.13	
Cost of Miscellaneous Sales	705.34	1,731.49	3,504.28		1,772.79
S.A.E. Operation and Maintenance Committee		150.79	10.59	140.20	
S.A.E. Production Committee		.34	1.18		.84
General Expense	9,804.91	25,259.55	23,623.36	1,636.19	
TOTAL EXPENSE	$30,515.13	$92,006.92	$82,297.10	$9,709.82	
Net Unexpended Income	$1,360.90[b]	$1,790.73[b]	$9,484.78		$11,275.51

[a] Ticket sales deducted.
[b] Net loss.

continually audited and written down as far as consistent with good business. The assets of the Society represent as near true values as can be arrived at. The business administration of the Society under our genial General Manager, Coker F. Clarkson, is all that could be desired and is the envy of many similar organizations.

C. B. WHITTELSEY,
Treasurer.

Urban Population in 1950

ASSUMING that the present rate of growth in the large American cities continues for the next 20 years an appalling city problem will require solution. New York City and its environs will have a population as large as that of Belgium while Chicago will have almost as many inhabitants as Sweden. Philadelphia and Boston with their surrounding suburbs will each be as populous as the Colonies when the Declaration of Independence was signed. Pittsburgh, Baltimore, Buffalo, Cleveland, Seattle, St. Louis, and San Francisco will have more than 1,000,000 inhabitants each, and in fact if the first-named municipality were to annex the cities that cluster around it it would be in that class today. If the other cities that are nearing or passing the 250,000 mark and the many cities nearing or passing the 100,000 mark are included, the number of people that will be gathered in these great centers approximately 20 years hence will be fully five times the population of the towns, country villages and farms.—*Kablegram.*

News of Section Meetings

(*Continued from p. 158*)

Mr. Thoms also owned up to a large amount of work devoted to manifolds, which are of a low-velocity type for the sake of high-speed performance. Provision is made for the distribution of liquid fuel in the manifold at low speed and open throttle.

After a year's experience with a four-speed transmission in one model, this transmission has been adopted for all models except the smallest six. With axle ratios between 3.6 to 1 and 3.9 to 1, the resulting sensation of a speed of 45 m.p.h. when the actual speed is 60 m.p.h. is very satisfactory.

Pierce-Arrow Has Aluminum Cylinder-Head

Pierce-Arrow cars were represented by John C. Talcott, chief experimental engineer, who said that the main change in these cars is the introduction of Series 81, which has an entirely new chassis. Series 36 with 137-in. wheelbase is essentially the same as last year. The new car has 130-in. wheelbase and the engine has six 3½ x 5-in. cylinders. The main difference between this car and the previous Model 80 is that it has been made lower and this has been done with the sacrifice of no head-room and little ground clearance. The interior has been improved and the rear seat made wider, due to 59-in. tread in the rear axle. An etched silver plate carries all the instruments, including a long-distance type thermometer and an electric gasoline gage.

The chassis has a centralized oil system feeding all the parts requiring frequent lubrication, and it is optional with the purchaser whether he has lamps mounted separately or built into the front fenders.

An aluminum cylinder-head is a unique feature of the new Pierce-Arrow engine. Aluminum alloy is used also for the connecting-rods and pistons. The compression ratio is a little less than 5 to 1. Although this was one of the first companies to use the Lanchester vibration dampener, the dampener was found unnecessary in this engine. More manifold development was registered here and even distribution has been gained by making the distance equal from the carbureter to each valve. The heat of the manifold has been reduced. About 25 per cent has been added to the power of the engine and the car with a coupé body and two passengers accelerates from 10 to 40 m.p.h. in 12 4/5 sec. Maximum actual speed is about 70 m.p.h.

Box-Section Frame in the Stearns-Knight

Chief engineer W. E. England spoke for the Stearns-Knight line for 1928, which comprises one six-cylinder and three eight-cylinder chassis. The six-cylinder and one of the eight-cylinder cars are the same as last year, but a new de luxe line with chassis of 137 and 145-in. wheelbase has been added. The engine has 3½ x 5-in. cylinders with Knight sleeve-valves and develops 112 hp. at 2800 r.p.m. This new line has new frame, brakes, radiator, and fenders, in addition to a new crankcase. Novel features are included in the tapered frame which has 7¾ in. deep side-members straight in plan, joined with five tubular and three pressed-steel cross-members. The front portion of the side member is reinforced with a steel channel 71 in. long, riveted into the side member in such a way that a box section is formed. Thus instability of the transmission and of the radiator and other forward units is overcome. The cross members and gussets result in a very rigid unit. The engine is supported at four points. The two in front are bolted fast to brackets through fabric and rubber, while the rear is supported on Biflex hangers consisting of 5-in. square sections, ⅜ in. thick, mounted vertically between the frame and the engine arm. Although almost integral with the frame, the engine is completely insulated from it.

Provision is made in the crankcase for mounting the starting-motor on the left side of the engine for right-hand-drive export cars. The flywheel housing has been enlarged to the No. 3 S.A.E. size to accommodate a larger flywheel. The larger gear on this flywheel results in 11½ per cent greater cranking torque with a loss of 7 per cent in the cranking speed.

An enlarged radiator of new design, retaining Stearns characteristics including its white line, has 14 per cent more frontal area and is 1 in. deeper. The radiator cap is plain, without emblem or moto-meter.

A new 20-in. two-blade fan is located at the center of the radiator, instead of at one side as was the former four-blade fan. Full-crowned fenders with 72-in. over-all width have a bead making a continuous line with the running-board molding, which latter is of chromium-plated steel, 2 in. deep, attached to the wooden running board with blind screws.

Among the new features of the bodies are seats both wide enough to accommodate three passengers comfortably. A rear tread of 59⅞ in. allows a rear seat 49 in. wide. Ventilation of the driver's compartment is through a large cowl ventilator leading air through two ducts in a false dash. A fine-mesh screen shuts out insects, and drains are provided so the ventilator can be used in wet weather. The hand-brake lever has been moved forward. Floor boards in the front compartment are now made of wood for greater comfort, and a spring-type removable plate is placed over the battery to provide for inspection and filling without removing the floor boards.

Stutz Dared To Send Service Manager

In introducing service manager Bert Dingley, who spoke for the Stutz car, Chairman Lowe said that he had just received a note asking if it was necessary to have "one of those new low hats" to be able to get into the new Stutz car.

Mr. Dingley failed to reply, but registered a complaint that the Metropolitan Section still considered service last, like the dog's tail, and still worse, that he was named as the 13th speaker on the list. A service manager has much trouble to contend with in any case, taking up where the engineer leaves off. After all the stories told by engineers, Mr. Dingley promised facts.

After complaints from the service division, the engineering department eliminated shimmy and tramp in the Stutz car by increasing the cross-section of the axle I-beam, enlarging the steering-knuckle pins and changing the steering ratio to 15 to 1. There was a little vibration and rumble in the engine at the peak of the torque, 1800 r.p.m. The 47 engineers tried everything. Finally a clutch man said, "All you need is a flexible disc in the clutch."

Going back in the chassis, the teeth in the transmission gears have been widened ¼ in. There was complaint of a whip in the propeller-shaft that could not be cured by saying, "You did not lubricate properly. Had you read the instruction book..." Finally the diameter of the shaft was increased and its wall thickness reduced so that the period has been eliminated. Little things like that have been the changes. During the public competitive tests a tendency was found for the large end of the aluminum-alloy connecting-rods to open up. The bearing would be too loose in summer and too tight in winter. Steel ends applied to the alloy rods have eliminated that trouble. Also an improvement was desired in acceleration at a certain

speed at which the car acted as though some one had dropped an anchor, and that anchor caused trouble in the service department. The cure for that was found, probably by an engineer, by removing a section of the continuous gasket at the manifold and allowing the passage of a portion of the charge over the heated surface between the ports.

Not to be out-done by the claims of engineers, Mr. Dingley said that the Stutz is the undefeated stock-car champion for 1927 in competitive public tests. They can take a production engine with a 5 to 1 or a 5½ to 1 compression ratio at random and it will develop 110 to 120 hp. on the dynamometer, "and they *are* horses". A compression ratio of 6 to 1 also is optional.

When the higher speeds are reached, about which the engineers speak so glibly, it is necessary to have good deceleration. For the sake of this, brake drums on the Stutz have been changed from 14 to 16-in. diameter and their operation from hydrostatic to hydraulic. From a speed of 20 m.p.h. the car can be stopped in five-eighths of its length; and from a speed of 60 m.p.h. in 10 car lengths.

With his exceptionally good delivery and breezy manner, Mr. Dingley sent every one home laughing. The only exceptions were a few of the most far-seeing engineers, who were visibly worried about what might happen if the service managers of their factories should be let loose unmuzzled before all their troubles are cured.

VALVE RECONDITIONING STUDIED

New England Section Told, by Jack Frost, of Servicing, Machines and Methods

Assembling at the Engineers Club in Boston on Jan. 11, the New England Section meeting opened with Fred W. Herlihy asking the cooperation of the members of the Section in securing a mailing list for a membership campaign that now is under way. Section Chairman F. E. H. Johnson announced that the next meeting would be on the subject of brakes, and also repeated the announcement of the beginning of the service course on automobile starting, lighting and ignition at the Massachusetts Normal Art School.

Introduced to speak on the subject of valves, Jack Frost of the Willis-Jones Machinery Co., Seattle, said that other noises and troubles in the engines have been largely eliminated but few engines cover very great mileage without some valve trouble. If a valve and its seat are both in perfect alignment with the valve-stem and guide, only 0.0015-in. clearance would be necessary between the stem and the guide to allow perfect valve action, but eccentricity and warping make greater clearance necessary. Cast iron warps in cooling and for some time afterward. For this reason a cast-iron valve that has been in service for some time and then reconditioned, is better than a new valve. When a warped valve is ground to a seat it will, in closing, make contact first on one side. When running at very high speed, leakage and burning can occur before the valve is completely seated. An elusive noise also results sometimes from the final seating of the valve.

The amount of side clearance is a matter of opinion and the cause of many arguments. A very large proportion of motor-car manufacturers is now using valves developed to resist warping and burning. The motorist still has to buy new valves and complains of their higher cost.

Tools have been developed for refacing both the valve and its seat. These have resulted only in an easier method of reconditioning than by grinding alone. The reseating tool depends for accuracy upon its fit in the valve guide, which may be imperfect.

Replacement seats now are available. In developing them it was necessary to find a metal that will not shrink and become loose in the counter-bore, that is tough enough to stand driving into place and hard enough to withstand the hammer blows of the valve. The material can be of higher quality than would be warranted for use in the whole cylinder block. When the replacement seat does become worn, it can be replaced again without the use of the replacement-seat cutter.

Mr. Frost said that the manufacturer not only is giving the motor-car purchaser an attractive car but is selling satisfactory automobile transportation. Well-equipped service-stations are necessary to make this transportation service what it ought to be.

In answer to questions in the discussion, Mr. Frost said that ethyl gas has seemed to cause more trouble with burning than does the ordinary gas, but burning is always due to misalignment or warpage. Mercury-cooled valves are too expensive to be available for automobile production. Some of the airports that are using replacement seats in aircraft engines report that mercury valves burn out the same as others.

There is no kind of valve that cannot be burned. Service men have tried to remedy the trouble by changing the valves even when trouble is with the seat.

Brake testing and recent brake developments is the subject of the next meeting of the New England Section, which will be held at the Engineers Club in Boston on Feb. 8, at 8 p. m. The meeting will be preceded by a dinner at 6:45. The speakers will be A. Vance Howe, of the Westinghouse Air Brake Co., Boston; Charles F. Smith, of the Brake Synchrometer Co., Boston; and F. W. Parks, of the Cowdrey Brake Tester Organization, Inc., Fitchburg, Mass.

BATTERY AND MAGNETO IGNITION

Southern California Section Hears Addresses by E. E. Tattersfield and R. A. Parker

The comparative merits of battery and magneto ignition-system were expounded and discussed at the regular monthly meeting of the Southern California Section, held at the Los Angeles City Club on Jan. 13. One hundred and twelve members and guests were present at the dinner that preceded the meeting and this number was augmented by many others who came later. Ethelbert Favary, chairman of the Section, presided and introduced the speakers of the evening, E. E. Tattersfield, field engineer of Magneto Sales & Service Co., Los Angeles, distributor for Robert Bosch Magneto Co., and Robert Parker, of the Electrical Equipment Co., both of whom explained the fundamental principles upon which the operation of the magneto is based. Mr. Tattersfield's talk was illustrated with diagrams. Mr. Parker then traced the course of high-tension battery ignition-systems from the earliest days up to the present.

Probably the greatest factor in the practically universal adoption of the battery ignition-system so far as the automobile is concerned, said Mr. Parker, is first cost. As the battery was already supplied to the car regardless of the type of ignition, there remained only the providing of a coil and a timer-distributor. The ease of replacement of defective parts also facilitated its use. The fuel mixture in the cylinder of an internal-combustion engine, he continued, does not explode, it burns. The ideal condition would be practically instantaneous combustion at the top of the piston travel. The hotter the spark is, the nearer the firing-point can approach the dead-center. Loss of power can be traced many times to a weak spark. It is important that the ignition should not miss, for considerable bearing trouble and wear of universal-joints and differentials can be attributed to the resulting uneven flow of power. Ignition systems are designed to operate on a set voltage; a higher voltage subjects the entire system to a destructive strain, resulting

in rapid burning of the points, breaking down of the condenser or weakening of the coil.

A common cause of hard starting is the abnormal amount of current drawn by the starting-motor, which lowers the voltage to the ignition coil. High-speed engines have created a demand for more effective ignition, the single-point timer being superseded by the two-point timer, which, in turn, gave way to a two-point timer using a three or four-lobe cam that opened the points at different times, in other words, one-half as fast as the previous igniter. This involves the use of two coils, one for each set of points.

A New High-Speed Magneto

In the discussion that followed the presentation of the papers, and in reply to a query from Chairman Favary, Mr. Tattersfield described the super-energy magneto, which has been built especially for use on engines having high compression and high speed. In such magnetos, said Mr. Tattersfield, the interrupter operating lever has been made lighter, the spring has been strengthened for quick action, and the number of turns of the winding has been increased to raise the voltage to approximately 30,000. Permanently grease-lubricated ball-bearings are now used and the oil-cups have been taken off. Terminal nuts formerly on the outside have been placed on the inside. This makes the magneto more compact, more smooth and more watertight. Increase in the voltage is made necessary by the increase in the resistance of the air-gap as the compression becomes greater.

Among the other points brought out in the discussion was the fact that high voltage is essential to insure the production of a spark regardless of the composition of the mixture or of the range of speed of the engine. In reply to further questions, both Mr. Tattersfield and Mr. Parker expressed preferences for the magneto system, Mr. Tattersfield believing that the ignition unit lasts longer than that of the battery system and gives better performance over a period, say, of 2 years, and Mr. Parker, that the spark from the magneto is superior to that from a battery. In a battery system, said Mr. Parker, the spark is like a blow from a hammer falling by gravity, while in the magneto system additional force seems to be added.

E. B. Moore, of the Los Angeles Creamery Co., declared that, in his opinion, both systems had their place, that some engines cannot be started with a magneto and can be started with a battery. The life of impulse starters in his service is only about 2 or 3 weeks, because the engine runs about 9 hr. per day and in that time makes about 300 stops.

Battery ignition was said to be used on airplanes because a battery is necessary for operating the radio and the use of two systems of ignition would entail the carrying of unnecessary weight.

According to G. A. Dailey, both systems, operating independently, are used on the motorcoaches of the Pickwick Stage Co., to insure that the coaches will reach their destinations, but he said that the smoothest operation is given by the magneto. W. F. John, of the Los Angeles Road Department, concurred with this statement, adding that the battery system, however, was the cheaper of the two.

John Wiggers, chief engineer of the Moreland Motor Truck Co., Burbank, Cal., said that he favored the battery system.

T. H. Harkness, of the Rolls-Royce of America, Inc., believed that double-battery ignition is better than magneto and battery ignition combined for the reason that it is possible to synchronize the sparks over the entire range and have good strong sparks and easy starting.

In reply to a query, Mr. Tattersfield stated that ignition points contain about 17 per cent of platinum, and about 20 per cent of iridium, and that platinum will withstand greater heat than will tungsten. In England, he said, a silver and nickel alloy is used but it is not so durable as platinum. In a battery system, however, the heat is not so great as in a magneto system and the use of platinum points is not necessary.

When used in a magneto, tungsten oxidizes, asserted Mr. Smith, of the Whiting-Mead Co., so that, at the starting speed, no spark can be obtained; at higher speeds, however, the current is strong enough to break down the oxidation and the spark is produced.

Preparing for and Making a Feature Flight

Northern California Section Hears Commander Noville Tell About the Byrd Transatlantic Flight

Members of the Northern California Section could not wait to finish their dinner on Jan. 12, before beginning the discussion of the evening. During the dinner at the Engineers Club, Chairman W. S. Penfield called on E. C. Wood, of the Pacific Gas & Electric Co., who bespoke cooperation of the members in the work of the Operation and Maintenance Committee.

The chairman also called for discussion on the question of lighter bodies. Some of the members are interested in this question and others are not. H. A. McKim, of the Standard Oil Co. of California, said that 2000 gal. of gasoline can be carried on a six-wheel truck. With an aluminum body, it would be possible to carry 200 gal. more. He spoke of legal restrictions that might prevent the use of other than steel tanks. E. Meybem, who is officially connected with the City of Berkeley, said that an ordinance is now being drawn up in that city and expressed the hope that it might be uptodate in this respect. Evidence was given by Commander Noville and Chairman Penfield that aluminum alloy is not corroded by gasoline. According to W. W. McDonald, all the ordinances are based on riveted tanks and they are obsolete, as welding is now used on steel tanks.

When the meeting was called to order after the dinner, H. L. Hirschler, of the Program Committee, announced that at the next meeting there will be shown motion pictures of the construction and assembly of the new Ford car. An engineer from the factory will be at the meeting to answer inquiries, particularly in regard to maintenance and operation of the car. Chairman Penfield then extended an invitation for new members to the Society, stressing particularly the advantages to be gained by service men and citing the brake tests that have been reported in The Journal.

Mr. Wood was called to the chair for the remainder of the meeting and introduced Mr. Salzman, an engineer of the Breese Aircraft Co., who was working with Lieutenant Pond in preparation for an attempt at the airplane endurance record. Several previous attempts had been made with the same plane before it took off with a load of 1400 gal. of gasoline and flew for 49 hr. and 28 min.

Another attempt was to be made, with 1550 gal. of gasoline and 270 lb. of oil, making a gross load of 16,000 lb. The plane will be loaded 25 lb. per hp. and 23 lb. per sq. ft. of plane surface. This is said to be 1 lb. heavier loading than has ever been given an airplane before.

Then came the main speaker of the evening, Commander

George Noville, U. S. N., who accompanied Commander Richard E. Byrd, U. S. N., on his transatlantic flight and is now connected with the Standard Oil Co. of California.

Preparation Was Long and Thorough

Preparation for the transatlantic flight occupied an actual period of 6 months and 2 days, including the selection of the type of airplane, overseeing the construction of the plane and engine, and securing the secondary equipment of instruments, navigating equipment, radio and emergency equipment.

After briefly describing the plane and its equipment, Commander Noville said that the plane was ready for its tanks in April. The location of these tanks had to be studied to preserve the balance of the plane as the tanks were emptied during the flight. Four 100-gal. tanks were placed in the wings and an 850-gal. tank was located just back of the center of gravity of the airplane. In addition, ten 5-gal. cans were carried in the flying cockpit to be emptied into the main tank after 50 gal. had been consumed. As a safety measure, there were three separate gasoline lines running to each carbureter and three separate oil lines.

Emergencies were provided for by various drills so that every man knew his exact position and duty in case of fire or a forced landing on water or land. To simulate an absolutely dark condition, the aviators pasted black paper over the windows and practiced flying by instruments alone. They tested the radio and the emergency boats; and they tested the fuel consumption and speed of the airplane to determine the most economical speed.

They also determined how far they could fly with two engines with a given load and prepared a curve that would give the mileage, speed and fuel consumption at various speeds. It was a complicated chart but in case of engine failure at any point over the Atlantic they could look on the chart and immediately determine how much gasoline they should dump to be able to reach shore with two engines. Tests also were made with various loadings to determine the time required to take off.

The only accident that occurred during this period of preparation came after the plane had been flown only 45 min., when it landed on a soft field, struck a rut and turned over. Every member of the crew went to the hospital and Floyd Bennett was so badly injured that he had to be replaced by Bert Acosta.

The Zero Hour Came at Length

Commander Byrd notified the Navy Department and the Weather Bureau on April 20 that he was ready to go, but it was not until June 28 that permission was received and the flight started in the rain at 5 a.m. on June 29. The rain lasted until noon, at which time the flyers passed over Cape Cod and headed over the open water for Nova Scotia, which they reached that afternoon in clear weather.

As expected, fog was encountered at the Newfoundland Coast. Instead of lasting about 2 hr. there was 19 hr. during which neither sea nor sky could be seen. When 1100 miles out to sea, they received news from a Swedish ship that Lieuts. Albert Hagenberger and Lester J. Maitland had just landed in Honolulu, and the flyers sent a message of congratulation to them from the middle of the Atlantic Ocean.

Only once during the 19 hr. was there any alarm. Every one but the man at the wheel was dozing, and probably he was dozing too. All hands were awakened by the roaring of the engine, which must have been turning about 3000 r.p.m. This could only occur when the plane was "on her nose." The pilot carefully righted the plane, and it was well that they had 10,000 ft. altitude. A few moments later they received a note from Commander Byrd, who was in the aft compartment, asking the pilot why he did not turn around and head for Paris instead of for New York City.

At the end of the 19 hr., clear weather was reported on the surface by a steamship, and the flyers came down to an altitude of 2000 ft., which was held until they reached the French coast at 7:15 p.m. They passed Brest at 8:15, turned north to pick up the Seine and then turned east. Ahead they could see three converging storm areas. They tried to pass the clouds before they came together but failed in this and had rough riding with plenty of rain and lightning for about 25 min.

The Earth-Indicator Compass Went Wrong

After flying 2½ hr. from Brest the fliers should have been at Paris. Instead they saw a lighthouse and knew that something must be radically wrong. A check showed that the earth-indicator compass, by which they were flying, was deranged.

By that time the weather was bad and they had to fly low to distinguish even lights, which were only a glow from an altitude of 300 ft. After correcting their course they reached Chartres, 30 miles from Paris. Between there and Paris they checked the fuel and found they had enough for 3 hr. flying, so they headed for the English Channel to avoid the danger of a forced landing on land in the fog. Rain was then falling in sheets and neither windshield nor goggles could be used. It was impossible for one man to pilot the plane more than 5 or 6 min. at a time.

At 3 a. m. a lighthouse showed that they had reached the vicinity of the Channel and they flew out 2 miles to avoid fishing boats that might be anchored at the shore. They prepared for a crash, as in their drills, by "clearing the ship" of radio, navigating instruments and everything sharp or heavy that might be torn loose and by kicking out the windows.

At an altitude of 100 ft. a calcium flare was dropped. A diffused glow appeared, but no water. Then they came down to 50 ft. and everyone was braced for the crash, because altimetres are not accurate below 100 ft. When the landing gear struck it was taken off as a unit and then the plane nosed over in 18 ft. of water.

Commander Byrd was thrown out the window; Acosta was thrown out of the cockpit, Commander Noville was thrown under a tank and Balchen was pinned in the nose of the plane, remaining under water 3 min. They all escaped with no serious injury except that Acosta's shoulder was broken.

The tail of the airplane was projecting from the water at an angle of 45 deg. and the buoyancy of the empty gasoline tanks caused it slowly to rise, backing out of the water. After the plane was on the surface, the emergency compartment was ripped open and the rubber boat was pulled out and inflated. It was loaded with records of the voyage, water stills, food and navigating instruments. The last articles were included for fear the flyers might be washed out into the Channel. As a tank containing about 45 gal. of oil burst with the impact, the flyers were well coated with the floating oil. After rowing about 400 yd., they were surprised to strike ground, and they found that the lighthouse was built on a knoll about 1½ miles inland.

Feature Flying Defined

In the course of the discussion, Commander Noville emphasized the distinction between commercial flying, feature flying and stunt flights. The last two are sometimes confused, but the term "feature flights" is used to designate flights that are undertaken to advance the science of aviation, while stunt flights are merely to attract public attention by something spectacular. In contrast with these, commercial flying is making records like 720,000 miles without serious accident.

Gasoline consumption during the Atlantic flight was at the rate of 10⅞ gal. per hr. for the 42 hr. On the North Pole trip, the party established a record for the Wright Whirlwind engine of 9.2 gal. per hr. per engine for 16 hr.

One inquiry referred to the difficulty of keeping a dump valve tight after it has once been opened. Commander

Noville said that a small leakage must be expected after the valve has been opened until it can be shellacked again. They did away with the oil-treated felt gasket and substituted a wax-impregnated leather gasket. A valve that will dump 850 gal. in 59 sec. and still weigh only 2¼ lb. must be a delicate instrument. A cork gasket also was mentioned as helpful.

In answer to an inquiry, the most economical flying speed was said to be with the engines throttled to 1450 r.p.m. At this speed the gasoline consumption was 7.7 gal. and the lubricating oil consumption was exactly 1 pt. per hr. per engine.

A description was given of the method of obtaining bearings by radio. The flyers call one ship. The ship operator turns his antenna to get the full volume of the signal and reports the angle. After securing the same information from another ship, the position of the airplane is readily found by triangulation.

At the close of the meeting, which was attended by about 60 members and guests, Professor Leslie spoke briefly of the aeronautical course that is being given at the Leland Stanford, Jr., University, with the help of an appropriation from the Guggenheim Fund.

FUEL QUALITY TENDENCIES

Antiknock Value and Effective Volatility Sought, Brown Tells Buffalo Section

In a paper on Present Tendencies in Motor-Fuel Qualities, presented by Prof. George G. Brown, of the University of Michigan, at the regular monthly meeting of the Buffalo Section on Jan. 3, Professor Brown said that the present tendency is away from misleading values, such as color and gravity, and toward the placing of emphasis upon the properties that influence the performance of the fuels in an engine; namely, antiknock value and effective volatility.

Ease of starting and satisfactory acceleration, particularly of a cold engine, demand high partial volatility even more than antiknock value, while the development of maximum power and a high fuel efficiency in modern automobile engines demand a relatively high end-point as well as antiknock value. Recent surveys of motor fuels marketed throughout the Country clearly indicate the present tendency to supply fuels of greater volatility in the first part of the distillation or of high partial volatility at low temperatures. Such fuels, said the speaker, exert a greater vapor pressure and have a greater tendency to vaporize. Too much heat in the carbureter and manifold therefore occasionally causes gassing in the carbureter and increases knocking. The oil industry is now investigating the relation between vapor pressure, volatility, dew-point and similar characteristics and engine performance. Hence we may expect within a few months to know what are the proper specifications for motor fuels to be used in engines that supply a certain quantity of heat to the intake manifold.

Our present knowledge indicates that the motor fuel giving the best performance in engines now in use is one that has a high partial volatility at low temperatures, a high partial volatility for acceleration and smooth running, and a reasonably high dew-point to prevent loss in power and increased fuel consumption in engines that supply a large quantity of heat in the manifold. It seems that there will not be an increase in demand for higher antiknock values because the gain obtained by increasing the compression ratio beyond 6 to 1 becomes relatively less and the difficulty of producing an extremely high antiknock fuel becomes increasingly greater as the antiknock value exceeds 45 or 50 benzol. With the increasing efficiency of the engine design, we should expect to have engines possessing compression ratios as high as 6 to 1 and still using what we may regard as ordinary gasoline having a value of 25 to 35 benzol based on present standards.

At the conclusion of the address there was considerable discussion of the subject by a number of the 46 members in attendance at the meeting, which was presided over by W. R. Gordon, Chairman of the Section. The paper and discussion are reserved for fuller presentation in a future issue of THE JOURNAL.

Army Motor-Vehicles

SPEEDOMETER, the U. S. A. Service motor-transport gazette, states that on Dec. 31 inventories showed approximately 20,500 motor-vehicles on hand in the United States Army. Compared with a year ago, these figures show a loss of approximately 3500 vehicles. At the end of the war the Army had in operation or in storage 275,000 vehicles, including some of practically every make and type then manufactured. The only new motor-vehicles that the Army has had since the war are 199 passenger-cars purchased during the fiscal years 1925 and 1926, and 148 passenger-cars purchased during the fiscal year 1927.

The highest mortality rate has been in motorcycles. While on June 30, 1927, there were reported on hand 2482 motorcycles, only 907 of them were in operation, the balance being not in running order and not economically repairable. Since June 30 there have been still more casualties, and on Dec. 5 the Quartermaster General of the Army stated that the point had been reached where the total elimination of all Harley-Davidson and Indian motorcycle models 1917 and 1918 is clearly in sight.

Dodge five-passenger cars, model 1917 and 1918, have also passed out of the picture at an alarming rate during the year just closed. Orders were issued to the field early in the year that none of the old models would be repaired.

The year 1927 ended with the following motor-vehicle set-up in the Army.

Tables of organizations of the active units of the Army plus allowances for camps, posts and stations, authorize the operation of 13,370 vehicles of the following types:

Motorcycles	2,482
Passenger-cars	953
Trucks, cargo	5,919
Ambulances	410
Omnibuses	387
Technical Vehicles	1,823
Trailers	1,396
Total,	13,370

January Council Meetings

A SESSION of the Council was held in New York City on Jan. 12, those attending being President Hunt; First Vice-President Wall; Second Vice-President Zimmermann; Councilors Chandler, Wooler and Veal; and Treasurer Whittelsey; also F. C. Whittington and E. W. Templin who had been nominated to serve on the 1928 Council.

A financial statement as of Dec. 31, 1927, was submitted. This showed a net balance of assets over liabilities of $204,630.79, this being $20,344.86 more than the corresponding figure on the same day of 1926. The gross income of the Society for the first 3 months of the fiscal year amounted to $90,216.19, the operating expenses being $92,006.92.

It was reported that a satisfactory contract for the 1928 Summer Meeting has been signed with the Chateau Frontenac, Quebec, the dates of the meeting being June 26 to 29.

The election of 54 members, 12 grade transfers, 2 reinstatements, 2 reapprovals, and 1 change in affiliate representation, on which the Council had acted by mail vote, were confirmed. Eighty-four additional elections to membership were approved, as well as 33 transfers in grade of membership. The resignations of 33 members were accepted and 7 reinstatements to membership were approved. One application was reapproved.

The following subjects were assigned to Divisions of the Standards Committee, as indicated:

- Sheet-Steel Thickness Tolerances—Iron and Steel Division
- Dome Lamps and Mountings—Lighting Division
- Three-Way Plugs, Connectors and Sockets—Lighting Division
- Woodruff Key-Seat Cutters and Gages—Production Division

At the session of the Council held on Jan. 24 in Detroit the following were present: President Hunt; First Vice-President Wall; Past-President Lítle; Second Vice-President Patitz; and Councilors Chandler, Sparrow, Veal and Wooler; Treasurer Whittelsey; also W. R. Strickland, H. T. Woolson and H. C. Dickinson, members-elect of the 1928 Council.

Twenty-one elections to membership were approved, as well as four transfers in grade of membership. The resignations of 15 members were accepted.

At the last session of the 1927 Council, held on Jan. 26, with President Hunt, First Vice-President Wall, Councilors Sparrow and Veal, and Treasurer Whittelsey, present. the reports of Divisions of the Standards Committee as accepted at the session of the Committee held on the preceding day were approved for submission to letter-ballot of the voting members on final adoption.

Organization Meeting of 1928 Council

The organization session of the 1928 Council was held in Detroit on Jan. 26, with the following in attendance: President Wall; Past-President Hunt; First Vice-President Strickland; Vice-Presidents H. C. Dickinson, L. M. Woolson and H. T. Woolson; Councilors Sparrow, Templin, Veal, White, and Whittington; and Treasurer Whittelsey.

President Wall announced the personnel of the 1928 Administrative and Research Committees as follows:

CONSTITUTION COMMITTEE

F. E. Moskovics, *Chairman*

J. C. Chase
H. E. Coffin

FINANCE COMMITTEE

W. L. Batt, *Chairman*

Joseph Bijur
H. L. Horning
W. E. Kemp
C. B. Whittelsey

HOUSE COMMITTEE

C. L. Lawrance, *Chairman*

W. H. Beal
C. L. Drake
H. L. Spohn
S. B. Stevens

MEETINGS COMMITTEE

John Warner, *Chairman*

E. P. Blanchard
S. R. Dresser
A. W. Herrington
L. C. Hill
F. C. Horner
G. L. McCain
G. L. Martin
C. A. Musselman
W. R. Strickland
J. F. Winchester
H. T. Woolson

MEMBERSHIP COMMITTEE

F. K. Glynn, *Chairman*

Ferdinand Jehle
B. J. Lemon
D. C. Teetor
F. G. Whittington

PUBLICATION COMMITTEE

John Younger, *Chairman*

E. E. LaSchum
T. J. Lítle, Jr.
S. W. Sparrow
E. P. Warner

SECTIONS COMMITTEE

V. G. Apple, *Chairman*, Dayton

John J. Balsom, Milwaukee
J. S. Erskine, Chicago
F. K. Glynn, member at large
H. L. Hirschler, Northern California
E. W. Kimball, Buffalo
B. J. Lemon, Detroit
Albert Lodge, New England
E. F. Lowe, Metropolitan
F. C. Patton, Southern California
R. E. Plimpton, member at large
F. H. Prescott, Indiana
George Smith, Cleveland
E. W. Templin, Pennsylvania
C. H. Warrington, Washington
R. E. Wilson, member at large

The names of the members who will serve this year as Chairman and Vice-Chairmen of the Standards Committee and of its Divisions were reported. H. M. Crane will be chairman, and A. J. Scaife and W. R. Strickland vice-chairmen, of the Committee. The names of the Division Chairmen and Vice-Chairmen, as well as of those named by the Council for service this year on the various Divisions of the Standards Committee are listed elsewhere in this issue of The Journal; also the 1928 lists of members serving on various committees connected with the Standards work and other matters, and as representatives of the Society in the activities of other organizations or in work jointly conducted by the Society with other organizations.

RESEARCH COMMITTEE

H. C. Dickinson, *Chairman*

B. B. Bachman
O. C. Berry
R. W. Brown
W. G. Careins
F. F. Chandler
H. M. Crane
A. W. Herrington
E. R. Hewitt
H. L. Horning
H. A. Huebotter
J. H. Hunt
H. M. Jacklin
W. S. James
C. F. Kettering
W. E. Lay
B. J. Lemon
Benjamin Liebowitz
E. H. Lockwood
Neil MacCoull
F. C. Mock
A. L. Nelson
V. P. Rumely
S. W. Sparrow
William G. Wall
E. P. Warner
John Warner
R. E. Wilson
J. F. Winchester
A. M. Wolf

FUELS SUBCOMMITTEE

(Cooperating with the National Automobile Chamber of Commerce, the American Petroleum Institute and the American Society for Testing Material)

S. W. Sparrow, *Chairman*

B. B. Bachman	H. L. Horning
O. C. Berry	W. S. James
T. A. Boyd	C. S. Kegerreis
H. R. Cobleigh	C. F. Kettering
H. M. Crane	F. C. Mock
H. C. Dickinson	R. E. Wilson

J. F. Winchester

HIGHWAYS SUBCOMMITTEE

(Cooperating with the Rubber Association and the Bureau of Public Roads)

B. B. Bachman, *Chairman*

R. W. Brown	B. J. Lemon
H. C. Dickinson	Benjamin Liebowitz
W. E. Lay	J. F. Winchester

HEADLIGHT SUBCOMMITTEE

(Cooperating with the Illuminating Engineering Society)

H. M. Crane, *Chairman*

H. C. Dickinson	E. S. Marks
R. N. Falge	C. A. Michel
William Johnson	John Warner

RIDING-QUALITIES SUBCOMMITTEE

R. W. Brown, *Chairman*

F. F. Chandler	T. J. Lítle, Jr.
H. C. Dickinson	E. H. Lockwood
Tore Franzen	E. C. Newcomb
George Hallett	E. P. Warner
Benjamin Liebowitz	John Warner

The personnel of the Production Advisory Board and Committees will be published in the next issue of THE JOURNAL.

Aids to International Touring

IT is beyond controversy that, from the point of view of international automobilism, the world would be the better for a uniform system of cautionary and direction markers. This principle has been subscribed to at several international conferences, but it must be realized that, with so many other post-war liabilities of greater significance, the adherent nations cannot yet put precept into practice except on a small scale.

The main objective has, perhaps, been attained by securing general approval of the triangle to signify danger. This sign, which has been standard in Great Britain for nearly 25 years, is often to be seen today throughout Europe and in other parts of the world. It serves to give the motorist, when in a foreign country, a signal which he knows means danger. With this general warning he can proceed cautiously. The danger triangle and the notification of unguarded railway crossings are specially important to the international motorist.

Great work is being done by national touring and automobile clubs and associations to reduce danger on the roads. Generally they are acting in conformity with approved ideals, promulgated through the medium of the Alliance Internationale de Tourisme.

As with road signs, so with traffic signals, an endeavor is being made to secure uniformity. The question was discuseed at a meeting of the A.I.T. Executive Committee in Paris recently, and one may reasonably hope that before long a simple code of hand signals for motor drivers may receive international recognition. There are differences of practice in various countries and it is not easy to compose these, but at least the effort is being made.

The question of a uniform code of signals to be given by police officers presents some difficulty, but this also is the subject of international debate. I can illustrate one difficulty by mentioning that in some countries the driver is compelled by decree to signify, by sounding his horn in a prescribed manner, which way he wishes to turn. Without this, the police officer will not signal him on. The countries in question doubtless find this a good plan, but I cannot think that other countries will agree to adopt it in preference to their own simpler codes. This question is largely a matter for conference among the police authorities, but motorists should be consulted before any decision is arrived at, and I am authorized to say that the A.I.T is willing to cooperate with a view to framing standard rules.

So much has been said and written about the vexatious visa that I will assume the arguments in favor of its abolition are accepted by the majority of those who consider this paper. Apart from the question of expense, which for an extensive tour might amount to £5 or £8, there is the labor of securing the visas on the eve of departure. A visa omitted means that the motorist avoids the country in question. Recently 12,000 members of the American Legion came to Britain. The visa fees chargeable totaled £24,000. Had they not been remitted, this great party, it is reported, would not have visited this country. What is common sense in the mass is equally so for the individual. Rational views are prevailing. Already visas have been abolished by many countries, and the time may come when the passport itself, as well as the visa, will no longer be necessary for the tourist.

I believe it may be possible to agree upon a system of routes to be prescribed as international. The next step would be to secure Government recognition of these routes as roads deserving of special attention, not merely with regard to surface and signposts, but also in the matter of frontier crossings. By joint action we may hope that Europe will achieve transcontinental highways on which international traffic, both tourist and commercial, would circulate so freely and speedily that the schedules maintained by the railroads could be approached. Special motorways will some day be built in all directions, but, without waiting for these, the improvement of a classic system of the existing highways might well be projected.

The tourist today is confounded by changed names and names spelt sometimes in Roman and at others in unfamiliar characters on road maps. For some years to come it will remain the practice of the A.I.T. to give to its members both the old and the new names and to use Roman characters. I would suggest that, in the interest of international travel by road, names on signposts and names of villages, in countries where unfamiliar characters are used, should be displayed also in Roman lettering.—From an address by Stenson Cooke at the World Motor Transport Congress.

Personnel of 1928 Technical Committees

THE accompanying personnel of the technical Committees of the Society and of representatives on the committees of Governmental Bureaus and Departments and other organizations, appointed under the Standards Department activities, completes the personnel for 1928. The personnel of Special and Cooperating Committees of the Society and the representatives on other committees is published in this issue to give the members a more definite idea of the fields of work in which the Society is taking an active part and the men who are participating directly. The personnel of certain committees, especially the Standards Committee, changes more or less during the year but in general will remain as published herein.

The Standards Committee is divided into 22 main Divisions classified according to types of vehicle, major automotive component units, parts and materials. Divisions are appointed annually and handle groups of subjects. They are further subdivided into Subdivisions, each of which handles a specific subject.

Special and Cooperating Committees are appointed either temporarily or permanently to handle specific subjects or such subjects as may not come within the classification of the Divisions. Their reports, as a rule, are eventually passed upon by the Standards Committee.

The work of the Committees of Governmental Departments and Bureaus and of other organizations does not usually proceed through the Standards Committee but may be acted upon by the Council of the Society in special cases.

STANDARDS COMMITTEE PERSONNEL

H. M. Crane, *Chairman*	General Motors Corporation
A. J. Scaife, *Vice-Chairman*	White Motor Co.
W. R. Strickland, *Vice-Chairman*	Cadillac Motor Car Co.

AERONAUTIC DIVISION

E. P. Warner, *Chairman*	Assistant Secretary of the Navy for Aeronautics
Arthur Nutt, *Vice-Chairman*	Curtiss Aeroplane & Motor Co., Inc.
Archibald Black	Garden City, N. Y.
V. E. Clark	Buffalo
J. W. Crowley	National Advisory Committee for Aeronautics
J. F. Hardecker	Naval Aircraft Factory
C. B. Harper	Bureau of Aeronautics, Navy Department
E. T. Jones	Wright Aeronautical Corporation
I. M. Laddon	Consolidated Aircraft Corporation.
C. J. McCarthy	Chance Vought Corporation
Leslie MacDill	Air Corps
W. B. Mayo	Ford Motor Co.
G. J. Mead	Pratt & Whitney Aircraft Co.
L. B. Seymour	National Air Transport, Inc.
R. H. Upson	Aircraft Development Corporation
Edward Wallace	Glenn L. Martin Co.
K. H. White	Bellanca Aircraft Corporation of America
L. M. Woolson	Packard Motor Car Co.
T. P. Wright	Curtiss Aeroplane & Motor Co., Inc.
P. G. Zimmermann	Paul G. Zimmermann Metal Aircraft

AGRICULTURAL POWER EQUIPMENT DIVISION

G. A. Young, *Chairman*	Purdue University
O. B. Zimmerman, *Vice-Chairman*	International Harvester Co.
A. H. Gilbert	Rock Island Plow Co.
R. O. Hendrickson	J. I. Case Threshing Machine Co., Inc.
P. E. Holt	Caterpillar Tractor Co.
H. E. McCray	John Deere Tractor Co.
John Mainland	Advance-Rumely Co.
R. L. Miller	Huber Mfg. Co.
A. C. Rasmussen	Insley Mfg. Co.
O. W. Sjogren	University of Nebraska
O. W. Young	Hyatt Roller Bearing Co.

AXLE AND WHEELS DIVISION

L. R. Buckendale, *Chairman*	Timken-Detroit Axle Co.
O. A. Parker, *Vice-Chairman*	Parker Wheel Co.
B. B. Bachman	Autocar Co.
G. W. Carlson	Eaton Axle & Spring Co.
C. C. Carlton	Motor Wheel Corporation
G. W. Harper	Columbia Axle Co.
J. H. Hunt	Budd Wheel Co.
E. R. Jacobi	Kelsey-Hayes Wheel Corporation
W. F. Rockwell	Wisconsin Parts Co.
F. L. Sage	Graham Bros.
George Walther	Dayton Steel Foundry Co.

BALL AND ROLLER BEARINGS DIVISION

H. E. Brunner, *Chairman*	S. K. F. Industries
G. R. Bott, *Vice-Chairman*	Norma - Hoffmann Bearings Corporation
E. R. Carter, Jr.	Fafnir Bearing Co.
D. F. Chambers	Bearings Co. of America
L. A. Cummings	Marlin-Rockwell Corporation
T. C. Delaval-Crow	New Departure Mfg. Co.
H. R. Gibbons	Hyatt Roller Bearings Division of the General Motors Corporation
B. H Gilpin	Franklin Die Casting Corporation
F. W. Gurney	Marlin-Rockwell Corporation
H. N. Parsons	Strom Bearings Co.
W. R. Strickland	Cadillac Motor Car Co.
Ernest Wooler	Timken Roller Bearing Co.

ELECTRIC VEHICLE DIVISION

C. R. Skinner, Jr., *Chairman*	New York Edison Co.
C. J. Blakeslee	Walker Vehicle Co.
O. E. H. Froelich	Ward Motor Vehicle Co.
C. H. Meeker	Lansden Co., Inc.
H. M. Pierce	New York City
E. R. Pritchard	Commercial Truck Co.

ELECTRICAL EQUIPMENT DIVISION

A. R. Lewellen, *Chairman*	Chevrolet Motor Co.
D. M. Pierson, *Vice-Chairman*	Dodge Bros., Inc.
Azel Ames	Kerite Insulated Wire & Cable Co., Inc.
A. K. Brumbaugh	White Motor Co.

D. S. Cole	Leece-Neville Co.
W. S. Haggott	Packard Electric Co.
T. L. Lee	North East Electric Co.
B. M. Leece	Leece-Neville Co.
L. E. Lighton	Electric Storage Battery Co.
F. H. Prescott	Delco-Remy Corporation
B. M. Smarr	General Motors Corporation
T. E. Wagar	Studebaker Corporation of America
J. G. Wood	Olds Motor Works

ENGINE DIVISION

A. F. Milbrath, *Chairman*	Wisconsin Motor Mfg. Co.
E. S. Marks, *Vice-Chairman*	H. H. Franklin Mfg. Co.
Paul Bastian	Stutz Motor Car Co.
H. C. Blake	Foos Gas Engine Co.
R. J. Broege	Buda Co.
C. L. Cummins	Cummins Engine Co.
J. B. Fisher	Waukesha Motor Co.
J. D. Harris	McCord Radiator & Mfg. Co.
E. D. Herrick	Lycoming Mfg. Co.
C. B. Jahnke	Fairbanks, Morse & Co.
E. T. Larkin	Sterling Engine Co.
K. R. Manville	International Motor Co.
F. W. Sampson	Continental Motors Corporation
L. P. Saunders	Harrison Radiator Corporation
A. W. Scarratt	International Harvester Co.

IRON AND STEEL DIVISION

J. M. Watson, *Chairman*	Hupp Motor Car Corporation
A. H. d'Arcambal, *Vice-Chairman*	Pratt & Whitney Co.
J. R. Adams	Midvale Co.
R. J. Allen	Rolls-Royce of America, Inc.
A. L. Boegehold	General Motors Corporation
Henry Chandler	Vanadium Corporation of America
J. D. Cutter	Fafnir Bearing Co.
B. H. DeLong	Carpenter Steel Co.
F. P. Gilligan	Henry Souther Engineering Corporation
H. W. Graham	Jones & Laughlin Steel Corporation
H. L. Greene	Willys-Overland, Inc.
W. G. Hildorf	Reo Motor Car Co.
E. J. Janitzky	Illinois Steel Co.
J. A. Mathews	Crucible Steel Co. of America
W. C. Peterson	Donner Steel Co.
E. A. Portz	Central Alloy Steel Corporation
S. P. Rockwell	Stanley P. Rockwell Co.
R. B. Schenck	Buick Motor Co.
W. R. Shimer	Bethlehem Steel Co.
Ralph R. Teetor	Perfect Circle Co.
H. P. Tiemann	Carnegie Steel Co.
E. W. Upham	Chrysler Corporation
T. H. Wickenden	International Nickel Co.
O. B. Zimmerman	International Harvester Co.

ISOLATED ELECTRIC LIGHTING PLANT DIVISION

C. B. Jahnke, *Chairman*	Fairbanks, Morse & Co.
C. E. Becker	Stearns Motor Mfg. Co.
G. D. Becker	Underwriters Laboratories, Inc.
A. F. Brotz	Kohler Co.
E. Dickey	Delco-Light Co.
Robert Steck	General Electric Co.
H. L. Zabriskie	Diehl Mfg. Co.

LIGHTING DIVISION

C. A. Michel, *Chairman*	Guide Motor Lamp Mfg. Co.
R. N. Falge, *Vice-Chairman*	General Motors Corporation Research Laboratories
Clyde C. Bohner	Tung-Sol Lamp Works
H. S. Broadbent	Westinghouse Lamp Co.
R. E. Carlson	Edison Lamp Works of the General Electric Co.
A. W. Devine	Department of Public Works, Commonwealth of Massachusetts
H. C. Doane	Buick Motor Co.
P. J. Kent	Chrysler Corporation
A. R. Lewellen	Chevrolet Motor Co.
H. H. Magdsick	National Lamp Works of the General Electric Co.
Walter Spear	Cincinnati Victor Co.
W. F. Thoms	Indiana Lamp Corporation
T. E. Wagar	Studebaker Corporation of America

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H. C. Mougey, *Vice-Chairman*	General Motors Corporation Research Laboratories
Sydney Bevin	Tide Water Oil Co.
O. E. Eckert	Mid-Continent Petroleum Corporation
J. B. Fisher	Waukesha Motor Co.
J. C. Geniesse	Atlantic Refining Co.
W. H. Graves	Packard Motor Car Co.
W. S. James	Studebaker Corporation of America
C. M. Larson	Sinclair Refining Co.
K. G. Mackenzie	Texas Co.
H. J. Saladin	Standard Oil Co. of Indiana
F. D. Shields	Transcontinental Oil Co.
C. W. Simpson	White Motor Co.
H. G. Smith	Gulf Refining Co.
J. B. Terry	Standard Oil Co. of California
R. E. Wilson	Standard Oil Co. of Indiana

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C. A. Carlson	Remington Oil Engine, Inc.
N. E. Donnelly	Dawn Boat Corporation
S. Clyde Kyle	American Car & Foundry Co.
C. D. Salisbury	Winton Engine Works
Joseph VanBlerck	Joseph VanBlerck, Inc.

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S. W. Mills, *Vice-Chairman*	Pierce-Arrow Motor Car Co.
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L. H. Palmer	Fifth Avenue Coach Co.
A. W. Scarratt	International Harvester Co.
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F. A. Whitten	American Car & Foundry Motors Co.

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C. B. Franklin	Indian Motocycle Co.

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D. F. Myers, *Vice-Chairman*	Relay Motors Corporation

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W. J. Baumgartner	Relay Motors Corporation
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E. H. Grey	Gulf Refining Co.
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M. C. Horine	International Motor Co.
S. W. Mills	Pierce-Arrow Motor Car Co.
A. J. Scaife	White Motor Co.
A. W. Scarratt	International Harvester Co.
E. M. Schultheis	Timken Roller Bearing Co.
E. M. Sternberg	Sterling Motor Truck Co.

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W. H. Bassett	American Brass Co.
C. H. Calkins	Baush Machine Tool Co.
D. L. Colwell	Stewart Die Casting Co.
H. R. Corse	Lumen Bearing Co.
H. L. Greene	Willys-Overland Co.
J. B. Johnson	Air Corps
H. G. Lamker	Wright Aeronautical Corporation
H. C. Mougey	General Motors Corporation Research Laboratories
A. L. Nelson	Bohn Aluminum & Brass Corporation
W. B. Price	Scovill Mfg. Co.
W. R. Webster	Bridgeport Brass Co.
T. H. Wickenden	International Nickel Co.
O. B. Zimmerman	International Harvester Co.

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A. Boor, *Vice-Chairman*	Willys-Overland Co.
A. Altenberg	John C. Hoof & Co.
A. K. Brumbaugh	White Motor Co.
R. V. Hutchinson	Olds Motor Works
W. C. Keys	United States Rubber Co.
G. L. McCain	Dodge Bros., Inc.
Ivan Ornberg	Hupp Motor Car Corporation
W. J. Outcalt	General Motors Corporation
C. W. Spicer	Spicer Mfg. Corporation
F. G. Whittington	Stewart-Warner Speedometer Corporation
H. T. Woolson	Chrysler Corporation
G. W. Yanss	American Chain Co., Inc.

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H. C. Snow, *Vice-Chairman*	Auburn Automobile Co.
R. S. Begg	Jordan Motor Car Co.
S. R. Castor	H. H. Franklin Mfg. Co.
L. A. Chaminade	Studebaker Corporation of America
G. A. Delaney	Paige-Detroit Motor Car Co.
W. T. Fishleigh	Ford Motor Co.
W. H. Graves	Packard Motor Car Co.
J. B. Judkins	J. B. Judkins Co.
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G. W. Smith	Buick Motor Co.

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W. P. Michell	International Motor Co.
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C. Breer	Chrysler Corporation
C. C. Carlton	Motor Wheel Corporation
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D. H. Fenton	Fisk Rubber Co.
W. T. Fishleigh	Ford Motor Co.
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A. H. Knight	Dodge Bros., Inc.
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SUBCOMMITTEE XII ON METHODS OF CHEMICAL ANALYSIS OF COMMITTEE A-1 ON STEELS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS

J. R. Adams	Midvale Co.

SUBCOMMITTEE XV ON DIE-CASTING METALS AND ALLOYS OF COMMITTEE B-2 OF THE AMERICAN SOCIETY FOR TESTING MATERIALS

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COMMITTEE A-7 ON MALLEABLE IRON OF AMERICAN SOCIETY FOR TESTING MATERIALS

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Benjamin Liebowitz	New York City
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ROBERT F. HEBRON

THE operation and maintenance wing of the Society has lost a member of long experience in the death of Robert F. Hebron, which occurred on Jan. 2, 1928. His official title was superintendent of garages and he had been in charge of fleet operation and garages for R. H. Macy & Co., Inc., for over 21 years. Mr. Hebron was elected an Associate Member of the Society in June, 1926, and was transferred to Member grade in October of the same year. He was a member of the Metropolitan Section of the Society.

Born in Ireland in August, 1872, Mr. Hebron's first contact with the automotive industry was some 25 or 30 years ago at the Electric Vehicle Co., in Hartford, Conn. After 1 year with this company he served as foreman for the New York Transportation Co. for 2 years and then spent 2 or 3 years in charge of fleet operation for the New York Edison Co., before joining the Macy organization.

Standards Committee Meeting

(*Continued from p.* 172)

tive American Standard under A. E. S. C. procedure. The text of the revised report is printed herewith.

TINNERS', COOPERS' AND BELT RIVETS

Tabular Sizes.—The sizes of rivets as given for the respective types of rivets on Tables 1, 2 and 3 shall be considered standard. Other values for sizes of rivets may be used in catalogs in conjunction with the standard sizes; it being recommended, however, that the data be in such form as will make clear which are standard and which are not standard.

Proportions.—The proportions indicated below, in Tables 1, 2 and 3, for the heads and points of the respective sizes of rivets shall be standard; other proportions are to be considered special. In non-standard sizes of rivets, the heads and points shall be of the same proportions; the lengths of rivets covered by Tables 1 and 2 being determined from the table by interpolation.

Tolerances.—The tolerance on the nominal diameter of belt rivets shall be plus 0.002 in. and minus 0.004 in.

The tolerances on the body diameters of coopers' and tinners' rivets shall be those given in the following table:

Size (Inclusive)	Tolerances	
	Plus	Minus
8 oz.— 2½ lb.	0.002	0.004
3 lb.—10 lb.	0.003	0.006
12 lb.—16 lb.	0.004	0.008

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Rivet Material: Composition and Physical Properties.—(*a*) The steel from which the rivets are manufactured shall be made by the open-hearth process and conform to the following:

Manganese 0.30 to 0.50 per cent
Phosphorus not over 0.04 per cent
Sulphur not over 0.05 per cent

(*b*) The material, when tested, shall conform to the following:

Tensile strength, lb. per sq. in., 45,000 to 55,000.
Yield point, lb. per sq. in., 0.5 tensile strength.
Elongation in 8 in., minimum per cent=

$$\frac{1{,}500{,}000}{\text{Tensile strength}}$$

The elongation need not, however, exceed 30 per cent.

The preceding requirements are not applicable to tests on finished rivets. They are for general information only in régard to the production of suitable rivet material.

Physical Tests.—Rivets selected at random from each size shall comply with the following:

(*a*) *Cold Test for Ductility*

One-half of the rivets selected for each test shall be flattened to one-fourth of their original diameter, and then bent through 180

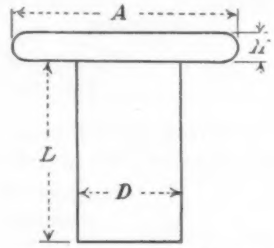


TABLE 1—TINNERS' RIVETS

Size No.	*D* Diameter of Body	*A* Diameter of Head	*H* Height of Head	*L* Length under Head
8 oz.	0.092	0.207	0.027	0.17
12 oz.	0.105	0.236	0.031	0.16
1 lb.	0.111	0.249	0.033	0.25
1½ lb.	0.130	0.292	0.039	0.24
2 lb.	0.144	0.324	0.043	0.25
2½ lb.	0.148	0.333	0.044	0.21
3 lb.	0.160	0.360	0.048	0.32
4 lb.	0.176	0.396	0.052	0.33
6 lb.	0.203	0.456	0.060	0.30
8 lb.	0.224	0.504	0.067	0.47
10 lb.	0.238	0.535	0.071	0.41
12 lb.	0.259	0.582	0.077	0.55
14 lb.	0.289	0.639	0.085	0.50
16 lb.	0.300	0.675	0.090	0.58

All dimensions given in inches

Approximate Proportions $A = 2.25 \times D$
$H = 0.30 \times D$

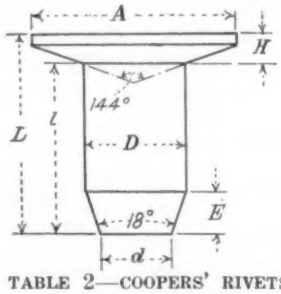


TABLE 2—COOPERS' RIVETS

Size No.	*D* Diameter of Body	*A* Diameter of Head	*H* Height of Head	*l* Length under Head	*L* Overall Length	*E* Length of Chamfer	*d* Diameter of Tip
1 lb.	0.109	0.245	0.032	0.187	0.219	0.043	0.098
1½ lb.	0.127	0.285	0.038	0.218	0.256	0.050	0.114
2 lb.	0.114	0.317	0.042	0.250	0.292	0.056	0.126
2½ lb.	0.148	0.333	0.044	0.281	0.325	0.059	0.133
3 lb.	0.156	0.351	0.046	0.312	0.358	0.062	0.140
4 lb.	0.165	0.371	0.049	0.343	0.392	0.066	0.148
6 lb.	0.203	0.456	0.060	0.406	0.466	0.081	0.182
8 lb.	0.238	0.535	0.071	0.500	0.571	0.095	0.214
10 lb.	0.250	0.562	0.075	0.531	0.606	0.100	0.225
12 lb.	0.259	0.582	0.077	0.531	0.608	0.103	0.233
14 lb.	0.271	0.609	0.081	0.562	0.643	0.108	0.243
16 lb.	0.281	0.632	0.084	0.593	0.677	0.112	0.252

All dimensions given in inches.

Approximate Proportions $A = 2.25 \times D$
$d = 0.90 \times D$
$E = 0.40 \times D$
$H = 0.30 \times D$

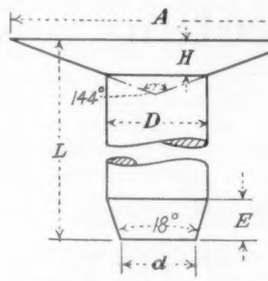


TABLE 3—BELT RIVETS

Size No.	D	A	H	L	E	d
	Diameter of Body	Diameter of Head	Depth of of Head	Length Overall	Length of Chamfer	Diameter of Tip
7 lb.	0.180	0.504	0.054	Lengths	0.072	0.162
8 lb.	0.165	0.462	0.044	to be	0.066	0.148
9 lb.	0.148	0.414	0.049	from 3/8"	0.059	0.133
10 lb.	0.134	0.375	0.040	to	0.053	0.120
11 lb.	0.120	0.336	0.036	3/4"	0.048	0.108
12 lb.	0.109	0.305	0.032	by	0.043	0.098
13 lb.	0.095	0.266	0.028	1/8" increments	0.038	0.085

All dimensions given in inches.

Approximate Proportions $A = 2.8 \times D$
$d = 0.9 \times D$
$E = 0.4 \times D$
$H = 0.3 \times D$

Tolerances.—The tolerances on the nominal diameter of belt rivets shall be plus 0.002 in. and minus 0.004 in.

deg. flat on themselves and shall show no signs of cracks, flaws or any other defects.

(*b*) *Hot Test for Ductility*

The remaining rivets shall be heated to a red heat and flattened to one-fourth of their original diameter, then reheated and bent through 180 deg. flat on themselves and shall show no signs of cracks, flaws or any other defects.

(*c*) *Hardness Test*

The hardness of rivets shall register between No. 20 and No. 26, inclusive, when tested by the Shore scleroscope. Any other degrees of hardness shall be considered special.

Finish.—The finished rivets shall be free from injurious defects.

SCREW THREADS DIVISION

ROUND, UNSLOTTED-HEAD BOLTS

(*Proposed Sectional Committee Report for Tentative American Standard, p. 127*)

TIRE AND RIM DIVISION

RIMS FOR LOW-PRESSURE TIRES

(*Proposed Revision of Present S.A.E. Recommended Practice, p. 127*)

THE DISCUSSION

H. M. CRANE, General Motors Corporation:—The Tire and Rim Division, after a year and a half of experience with the S.A.E. Recommended Practice now in the S.A.E. HANDBOOK, concluded that it would easily bear revision. At a meeting held in Detroit last December, the facts were investigated as to the probable use of various rim sizes during the ensuing year. On the basis of this investigation the Division unanimously recommended a revision of the table in the S.A.E. HANDBOOK to conform to the report printed on p. 127 of the January issue of THE JOURNAL.

MR. STRICKLAND:—I do not believe this recommendation is all-inclusive or practical except for the lighter cars. The 19-in. size is not all-inclusive and does not provide for the development of heavy cars; neither does the 20-in. rim.

MR. CRANE:—The Division adopted a policy in this respect based on simplification, and that consists, on the whole, in simplifying. It does not consist of adding to the table, but in subtracting from it. The old recommended practice included six rim sizes, and we decided that anybody who proposed to add a size to the six already in the table should suggest which one therein should be deleted. It is anyone's privilege to prove that a size proposed is not as good as another already in the table, not as a matter of opinion but as one of fact as to its use in a number of cars so equipped.

ATTENDANCE AT STANDARDS COMMITTEE MEETING

The members of the Standards Committee and the Society members and guests in attendance were:

Standards Committee Members

N. G. Anderson
B. B. Bachman
Joseph Berge
Sydney Bevin
C. J. Blakeslee
A. Boor
R. J. Broege
L. R. Buckendale
L. F. Burger
R. S. Burnett
L. A. Chaminade
Henry T. Chandler
C. F. Clarkson
H. M. Crane
B. V. Evans
R. N. Falge
J. B. Fisher
A. R. Fors
F. P. Gilligan
H. W. Graham
C. B. Jahnke
H. S. Jandus
E. J. Janitzky
O. C. Kavle
W. C. Keys
F. E. A. Klein
C. T. Klug
C. M. Larson
B. M. Leece
L. F. Maurer
C. A. Michel
H. C. Mougey
J. H. Nelson
Maurice Olley
Ivan Ornberg
W. J. Outcalt
D. W. Ovaitt
H. N. Parsons
D. M. Pierson
F. H. Prescott
H. J. Saladin
E. N. Sawyer
A. J. Scaife
R. B. Schenck
B. M. Smarr
W. R. Strickland
E. W. Templin
E. W. Upham
Marsden Ware
J. M. Watson
W. R. Webster
F. G. Whittington
Ernest Wooler
G. A. Young

Society Members and Guests

F. R. Alford
H. L. Ames
A. B. Aylesworth
O. Bachelle
F. E. Badge
J. R. Bartholomew
E. A. Bernhard
T. N. Bourke
L. B. Case
W. G. Clark
W. S. Clarkson
D. S. Cole
F. H. Colvin
Howard Cooper
D. S. Cox
D. Z. Dailey
C. N. Dawe
A. F. Denhan
C. L. Drake
F. J. Druar
O. E. Eckert
Graham Edgar
E. F. Ellis
E. W. Ely
R. A. Follensby
A. A. Gardiner
Walker Gilmer
C. P. Grimes
C. P. Guiness
A. W. Gutterson
A. G. Herreshoff
F. C. Horner
P. Insley
W. M. Johnson
E. W. Kimball
F. A. Kirkhoff
L. E. Leighton
S. F. Lentz
Albert Lodge
Neil MacCoull
A. F. MacDonald
C. R. Noll
A. W. Pope, Jr.
W. P. Putnam
A. W. Reader
H. E. Roese
George A. Round
F. W. Sampson
R. C. Sanders
E. S. Saugren
Curt Saurer
A. W. Scarratt
L. J. Schneider
A. A. Skinner
E. W. Stewart
J. C. A. Straub
T. P. Thomas
Hubert Walker
F. C. Walter
J. E. White
S. H. Whiting
R. E. Wilkin
G. W. Yanss
Alvin Yocum

The 1928 Annual Meeting

(*Continued from p.* 154)

a new discovery that liquid fuel can be ignited without being gasified, and this influences the time lag. J. H. Geisse, of the Naval Aircraft Factory, said that his impression from tests is that the time lag is related more closely to turbulence than to fineness of the spray.

Remarks on the comparative thermal efficiencies and mean effective pressures of the constant-volume and the constant-pressure cycles were made by Mr. Huebotter, based on computations from which he concludes that the highest efficiency is secured when the most fuel possible is burned at constant volume. Nevertheless, detrimental effects on the engine make it unprofitable to burn more than one-fifth of the fuel at constant volume. In the best practicable cycle, combustion raises the pressure from the 350-lb. compression to about 700 lb.

After a little discussion pro and con as to the value of turbulence, Chairman Norman said it was remarkable to what extent the same results can be achieved by different methods.

Charles B. Jahnke, of Fairbanks, Morse & Co., said that no particular type of engine is best in general. A Diesel engine depends on a delicate balance of various conditions. The engine is still in its infancy, particularly the solid-injection type, which has opened up new lines of development. European engineers tend toward complex designs and Mr. Jahnke looks for great improvement in Diesel engines in this Country.

The Diesel engine maintains its torque down to 25 per cent of its normal speed, at which point the fuel consumption is about 5 per cent higher than normal, according to Mr. Jahnke.

Horning Sees No Small Diesels

When called upon, Mr. Horning was reluctant to speak about Diesel engines. He said he was surprised to find that some of the German engineers lost interest in small Diesel engines when they were able to obtain gasoline at a little under 30 cents per gal. In the larger applications the economy of Diesel engines is important, but operators of smaller units are much more interested in the amount of work that can be done than in any economy in fuel.

For aircraft, L. M. Woolson, of the Packard Motor Car Co., said that the Diesel engine promises improvement in regard to fire hazard and cruising range. He is almost ready to prophesy that there will be no further great improvement in long-distance records until Diesel aircraft engines are developed.

A rail-car Diesel engine of 200 hp. was reported by Harte Cooke, of the McIntosh & Seymour Corporation. This engine drives a 94-ton car that seats about 50 people and has baggage space. It can be operated from either end and maintains a regular steam railroad schedule. This car runs 3 miles on 1 gal. of fuel. The McIntosh Corporation is now building a 900-hp. locomotive for suburban passenger service. Electric transmission is used with these.

S. T. Dodd, of the General Electric Co., said that his interest in Diesel-engine locomotives is due to their economy and cited a case in which a Diesel locomotive operated during a 24-hr. test ran on 130 gal. of oil and a steam locomotive the next day used 1370 gal. of oil. On a ton-mile basis, the Diesel locomotive moved 260 tons per gal. and the steam engine moved 26 tons per gal. Also the control of the Diesel locomotive required much less attention from the engineer than did the steam locomotive. General Electric Diesel locomotives run 24 hr. per day and 6 days per week, with adjustments on Sunday. No steam locomotive can stand this continuity of service, according to Mr. Dodd.

To illustrate the progress that has been made in Diesel engines, Hermann Lemp, of the Ingersoll-Rand Co., said that when he was with the General Electric Co., half a dozen years ago, he proposed in a meeting of the Society the use of Diesel engines with electric transmission for marine propulsion. At that time the conservative engineers threw plenty of bricks at him; but a few of the engineers have since picked up those bricks and are selling them.

Mr. Lemp reported running a 100-ton high-speed Diesel-engine locomotive with four coaches between Hornell, N. Y., and Meadville, Pa., a distance of 186 miles, with a consumption of only $7.40 worth of fuel and lubricating oil, representing a cost of about 1 cent per mile for each coach. The maximum speed was about 56 and the average speed about 35 m.p.h. The locomotive was operated by steam engineers who had never seen it before, after 40 min. instruction.

Huebotter Describes Aluminum-Alloy Pistons

Aluminum-Alloy Pistons was the subject of the last paper of the morning, presented by H. A. Huebotter, chief engineer of the Butler Mfg. Co. Describing the essential features of a successful piston without regard for their order of importance, he listed them as being (*a*) light weight, to minimize inertia forces; (*b*) high thermal conductivity and emissivity to improve heat dissipation, or refractory composition to withstand high temperatures; (*c*) proper bearing-fit in the cylinder at all operating temperatures; (*d*) strength adequate to withstand the maximum gas pressure in the cylinder; (*e*) effective sealing against the gas in the combustion-chamber and against the lubricating oil in the crankcase; (*f*) good bearing properties with normal lubrication; (*g*) ease of fabrication; and (*h*) resistance to corrosion in ordinary service.

Consideration of the foregoing requirements suffices to show, said Mr. Huebotter, that a piston must be the product of a number of compromises. A piston designed for high speed alone will fail when applied to heavy service, as it has not enough metal to conduct the absorbed heat or to carry the high fluid-pressures. A piston that runs cool indefinitely at full load is too massive for high speed, and the less important quality must always abdicate in favor of those which are imperative.

After mentioning the good properties of aluminum alloy, Mr. Huebotter went on to say that, among the present consumers of aluminum-alloy pistons in heavy-duty service are the motorboat and the gasoline-engine rail-car builders. Another class of service to which aluminum-alloy pistons are being applied successfully is represented by moderate-sized marine, railroad, and mobile industrial oil-engines operating on the Diesel or the modified Diesel cycle.

The major part of Mr. Huebotter's paper was devoted to pistons marketed under the name Bu-Nite, which are represented in practically every class of internal-combustion engine now in commercial use and are manufactured in sizes from 2 3/16-in. diameter, for gasoline racing engines, to 18-in. diameter for Diesel yacht engines. They illustrate certain methods whereby an aluminum alloy has successfully displaced gray iron in heavy-duty pistons. The metal used is an alloy of aluminum, copper, iron, and nickel, developed for and devoted almost exclusively to the manufacture of pistons and piston accessories.

Characteristics of the Bu-Nite piston are that the pressure is transmitted from the piston-head to the piston-pin

bosses through columns or struts and that diametral expansion of the skirt is controlled by steel bands that are embedded in the alloy when it is cast but are not bonded to it. Longitudinal slots cast in the piston allow the metal to expand more than the steel bands, the slots becoming narrower as the temperature rises.

Cross-sections and detailed descriptions of the different types of piston were presented in Mr. Huebotter's paper, and he said in conclusion that experience has proved beyond a doubt that the performance of large gasoline engines and of moderate-sized Diesel engines is improved by the use of the alloy piston. As the demand for a high power-to-weight ratio grows in the Diesel-engine industry, as it has in the automotive gasoline-engine industry, the aluminum-alloy piston will be accepted eventually as the heart of the engine.

After the presentation of Mr. Huebotter's paper, Mr. Sawyer of the General Electric Co. paid a tribute to the chairman of the meeting. He said that at the Ohio State University Professor Norman has classes with different names but the only subject he teaches is common sense. In applying common sense to the engine question, the gasoline engine should be used for intermittent service while the Diesel engine is better worth while for service of more than 8 hr. per day. It is important that an engine to be operated by more than one man should be more foolproof than is a gasoline engine. Apparently the Diesel will be the simplest and most successful for such work.

Varied Program Presented at the Engine Session

Fuel-Pumps, Supercharging, Industrial Uses for Automotive Engines and Multiple Ignition Studied

Four papers were presented at the Engine Session held on Wednesday evening, Jan. 25. The first was by A. M. Babitch, of the A. C. Spark Plug Co. In Mr. Babitch's absence, it was read by Frank N. Nutt of the same company and described the advantages to be gained by using a mechanical gasoline fuel-pump. The paper on Some Aspects of Supercharging for Sea-Level Conditions was by C. Fayette Taylor and L. Morgan Porter and dealt with the results of an investigation made under the auspices of the Massachusetts Institute of Technology. It was presented by Mr. Porter. Numerous new applications of the automotive engine in various industrial fields were cited by H. L. Horning, of the Waukesha Motor Co., who showed many lantern-slide views of these special applications and described them. And H. M. Jacklin, of Purdue University, presented a valuable paper on Improving Engine-Performance by Using Multiple Ignition. President-elect W. G. Wall was chairman. In the late evening, after the adjournment of the session, a buffet supper was served in an adjacent room.

Fuel Feed-Pump Advantages

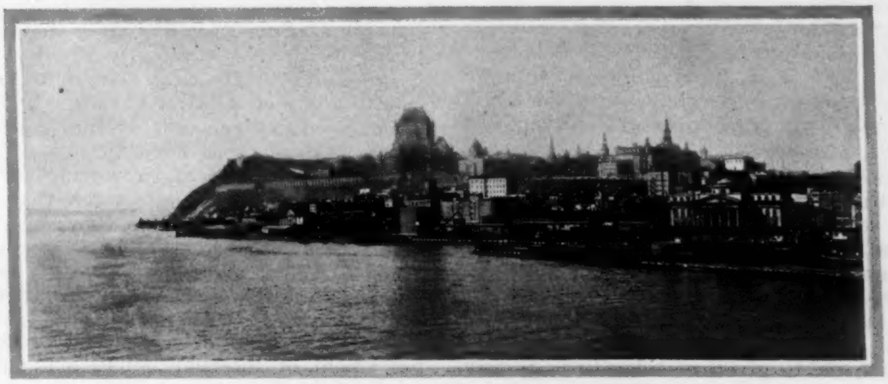
In his paper on the advantages of gasoline fuel-pumps over other gasoline-supply systems, A. M. Babitch said in part that fuel systems for automobiles, airplanes and motorboats, can be divided into (*a*) the location and storage of an adequate supply of fuel, (*b*) the mechanical means for bringing the fuel from the tank to the carbureter and (*c*) the necessary plumbing devices such as piping, fittings, strainers and valves. For automobiles, the fuel tank usually is placed between the frame side-members at the rear; but this arrangement precludes a gravity supply and modern practice has centered on either an air-pressure system or a vacuum tank.

After reviewing the essential features of the air-pressure and the vacuum-tank systems, the author said that a simple and complete solution of the fuel-supply problem is offered through the use of a mechanical fuel-pump. The system he described comprises a tank, a fuel-pump and two pipes. One of the pipes connects the tank with the pump and the other connects the pump with the carbureter. The pump is of the diaphragm type, operated by a lever that is given a reciprocating motion of from 3/16 to ¼ in. from a valve push-rod or from an eccentric located on the camshaft or on any other rotating part of the engine. The pump draws fuel from the main supply-tank through a strainer, which is a part of the pump unit, and feeds it under pressure to the carbureter. The output is in strict proportion to the requirements of the engine, and the average pressure at which the fuel is supplied is constant for each cycle of the engine.

Mr. Babitch said that several factors contribute to the long life of the unit and make it practically free from trouble. The diaphragm and valves are of non-metallic materials and tests show that they will operate indefinitely without attention. Straining the fuel and separating out the water and sediment before they reach the valves eliminates sticking or freezing of the mechanism as well as minimizing carbureter trouble.

It was brought out in the discussion which followed the presentation of the paper that the whole subject of fuel feed should not be treated entirely on the basis of how much fuel can be supplied, but that the subject should be considered from the angle of satisfactory carburetion. It was said that the fact is that constant pressure at the jets must be maintained as closely as possible if satisfactory carburetion is to be accomplished. It was said further that the only satisfactory way to do this is to maintain as nearly as possbile a constant level in the float chamber of the carbureter. The statement was made also that satisfactory carburetion is difficult to attain even when the fuel supply is perfect and that no fuel system will be considered successful if, in the opinion of the carbureter engineer, its operation in any way disturbs carburetion.

One objection made to the use of a mechanical fuel pump related to its ability to operate



Looking Ahead to the Summer Meeting—June 26 to 29

over a long period without building up pressure. It was said that the pressure when using a fuel-pump system is 2 or 3 lb. per sq. in., whereas the pressure in a vacuum fuel-system is approximately ½ lb. per sq. in. A point in favor of the fuel pump described was said by another discusser of the paper to be its applicability to airplane engines. It was said that the standard fuel-pump now used by the Air Corps is a gear-pump and that most airplanes carry a reserve gravity-feed supply of fuel sufficient for a 30-min. flight so that, at times, it may become necessary for the fuel pump to operate for this period after the main tank becomes empty. As the type of gear-pump now in use requires the flow of fuel for lubrication, a costly design and careful manufacturing are necessary to produce a pump that will run dry for 30 min. without causing trouble. In the diaphragm type of pump, all moving parts are lubricated adequately and the pump will operate indefinitely without the flow of fuel. If the type of pump described in the paper were substituted for the Air Service gear-pump, it would eliminate from the fuel system the fuel-pump-gland drain, two Type-B valves for bypass and relief, two T-fittings, three flexible-hose connections, seven union connections, and four fuel-lines. On supercharged airplanes, the supercharger fuel-relief valve would be eliminated also. A line from the pressure side of the supercharger runs to the under side of the pump diaphragm, balancing the supercharger pressure in the carbureter float-chamber and allowing the pump spring to maintain a constant differential fuel-pressure regardless of the amount of supercharging. It was stated also that this system of feeding fuel to supercharged engines has been tested in the laboratory under a wide range of supercharger pressures and has operated satisfactorily.

Supercharging for Sea-Level Conditions

One of the possible uses of supercharging is to secure increased output at sea-level from an internal-combustion engine of a given size, as was stated in the paper on the foregoing subject that was presented by C. Fayette Taylor and L. Morgan Porter. This application is particularly important where engine displacement is limited, as in automobile racing, and may become of importance in certain types of automobile and in aircraft where sea-level power-output greater than the normal is required temporarily.

Using an internal-combustion engine having a variable expansion ratio, the authors made a series of tests at normal atmospheric-pressure with a supercharger to secure increased power-output. These tests indicate the results in horsepower and efficiency that can be attained in automobile engines by independently varying the expansion ratio and the total compression-ratio. The theoretical horsepower and efficiency were computed for the conditions of the tests for purposes of comparison. The paper is printed in full elsewhere in this issue of The Journal and includes a series of curves which show graphically the results of variations in the different factors, as well as a comparison of the test results with the calculated values.

Following the presentation of the paper, one of the discussers said that the data given in it seem to establish conclusively the fact that there is an appreciable gain in power due to scavenging of the clearance volume with the use of a certain amount of supercharger pressure. Even with a comparatively small valve-overlap, there is an appreciable time when an excess of supercharger pressure in the intake manifold, over the exhaust back-pressure in the exhaust manifold, will serve to scavenge the clearance volume and force into the cylinder a greater weight of charge than that which merely corresponds to the filling of the displaced volume. There is also a gain due to decrease of dilution.

Another discusser said that, in the actual fitting of a supercharger to an engine, two additional factors not covered by the paper should be given consideration; namely, mixture temperature and spark advance. It was stated that in any given engine using a given grade of fuel, detonation depends on both the final temperature and the final pressure of the mixture and that each is important. An engine that is close to the detonating point may still be supercharged to a certain extent by cooling the mixture between the supercharger and the engine so that the final mixture-temperature does not exceed that of the supercharged engine. In any actual installation a certain amount of inter-cooling takes place, as the supercharger usually is built with cooling fins and manifolds often are ribbed to help carry away the heat. There is also a small additional amount of cooling due to better vaporization of the fuel as it passes through the supercharger. A properly designed inter-cooler would, of course, provide a still lower mixture-temperature. Since, for practical operation, any engine must be kept below the detonating point, the amount of spark advance is of importance.

In conclusion, Mr. Taylor stated that the work of the Massachusetts Institute of Technology is directed along fundamental lines to show what the underlying factors of supercharging are and not toward proving or disproving the merits of any particular kind of supercharger.

Industrial Uses for Automotive Engines

Quoting Herbert Spencer to the effect that the trend of human invention is from the ornamental to the useful, Mr. Horning said that the principle can be stated better by saying that, to survive, all forms of human invention must show an increase in usefulness, not only in their primary application but in collateral applications of even greater value than was their original object. In the last analysis the principle of the survival of the most useful, or the survival of the fittest, has enabled engineers to develop many new industries based on the fact that the automotive type of engine was much better than its original designers thought. Based upon the foregoing principle, the development of the automobile induced the development of the motor-truck, the taxicab and the motorcoach. Solving the problem of producing powerplants having light weight per horsepower solved the riddle of human flight, and the automobile took wings and became an airplane.

Following the application of the automotive type of engine to tractors about 1912, it was applied to large concrete-mixers in 1916, to power shovels or excavators in 1918 and to ditch diggers in 1919. It was applied to portable air-compressors in 1916. These new uses suggested numerous other applications which have solved the common-labor problems of recent years and which are the backbone of road building, structural building and the newer forms of public transportation.

In discovering new fields for the automotive type of engine, Mr. Horning said that utility has been the determining factor. It has been found that it requires about 5 years to induce a given industry to change from its use of the older sources of power to use of the automotive type. This has held true with machinery such as concrete mixers, power shovels, cranes, air compressors, ditch diggers, road machinery, tractors, and the like. In the field for the production of petroleum, in which there is a necessity for new special transmission-machinery to adapt the new power-source to the old speeds, the application of the automotive type of engine has, in a period of 3½ years, reached the point at which almost 10 per cent of the world's oil is being produced by such engines. Mr. Horning then went on to analyze some of the problems which must be solved during the process of converting an industry to the use of powerplants of the automotive type, showing and describing numerous lantern-slide views of special applications of this type of engine.

Improving Engine-Performance

Results of three sets of investigations looking to the improvement of internal-combustion-engine performance are set forth in the paper that was presented by H. M. Jacklin, associate professor of automotive engineering, Purdue

University. The first set was with multiple ignition, the second with high compression and the third with the comparative behavior of a variable-compression engine when operating as a constant-clearance engine and when operating with constant compression.

The tests with multiple ignition indicated that it increases the power about 9 to 10 per cent at full throttle and generally gives smoother operation than does ignition with a single spark-plug, especially on the leaner air-fuel mixtures.

Increasing the compression ratio from 5.3 to 1 to 10 to 1 resulted in a 13-per cent increase in the power developed.

Operating the engine on the constant-compression principle resulted in a fuel saving of as much as 34 per cent. The thermal efficiency was increased the same amount, and the exhaust temperatures dropped more rapidly at reduced loads under constant compression than in the conventional constant-clearance operation.

According to the author, fixed spark is entirely feasible under constant-compression operation. Combustion is much better than it is with constant-clearance operation, and this should result in less carbon deposition and less crankcase-oil dilution.

In the course of the discussion of the paper the question was asked whether, if the engine were designed with a combustion-chamber such that one spark-plug could have been located at its center, the same results could have been obtained with one spark-plug as with the multiple ignition. Professor Jacklin said in reply that the same results might be obtained, but mentioned the extreme difficulty of locating one spark-plug in the center of the combustion-chamber, especially in the overhead-valve type of engine. Another discusser said that in one instance a special spark-plug having very long electrodes which extended into the center of the combustion-chamber was used and that the results had been surprisingly good. Experiments comparing the effect of two spark-plugs diametrically opposed to each other and placed horizontally with the effect of one spark-plug located at approximately the top center were said by another discusser to have shown results within 1 to 3 per cent of each other, the difference being so slight that no real advantage was apparent.

SPEAKERS AT THE ENGINE SESSION

Col. W. G. Wall (Upper Right), Who Presided at the Engine Session; H. L. Horning (Upper Left), of the Waukesha Motor Co., Who Discussed Industrial Engines and Many Other Matters; F. G. Whittington (Lower Left), of the Stewart-Warner Speedometer Corporation, Who Discussed Gasoline-Supply Systems; H. M. Jacklin (Lower Center), of Purdue University, Who Discussed Multiple-Ignition and High-Compression Engines, and L. Morgan Porter (Lower Right), Who Discussed Supercharging

Executives Study Tire-Size Restriction

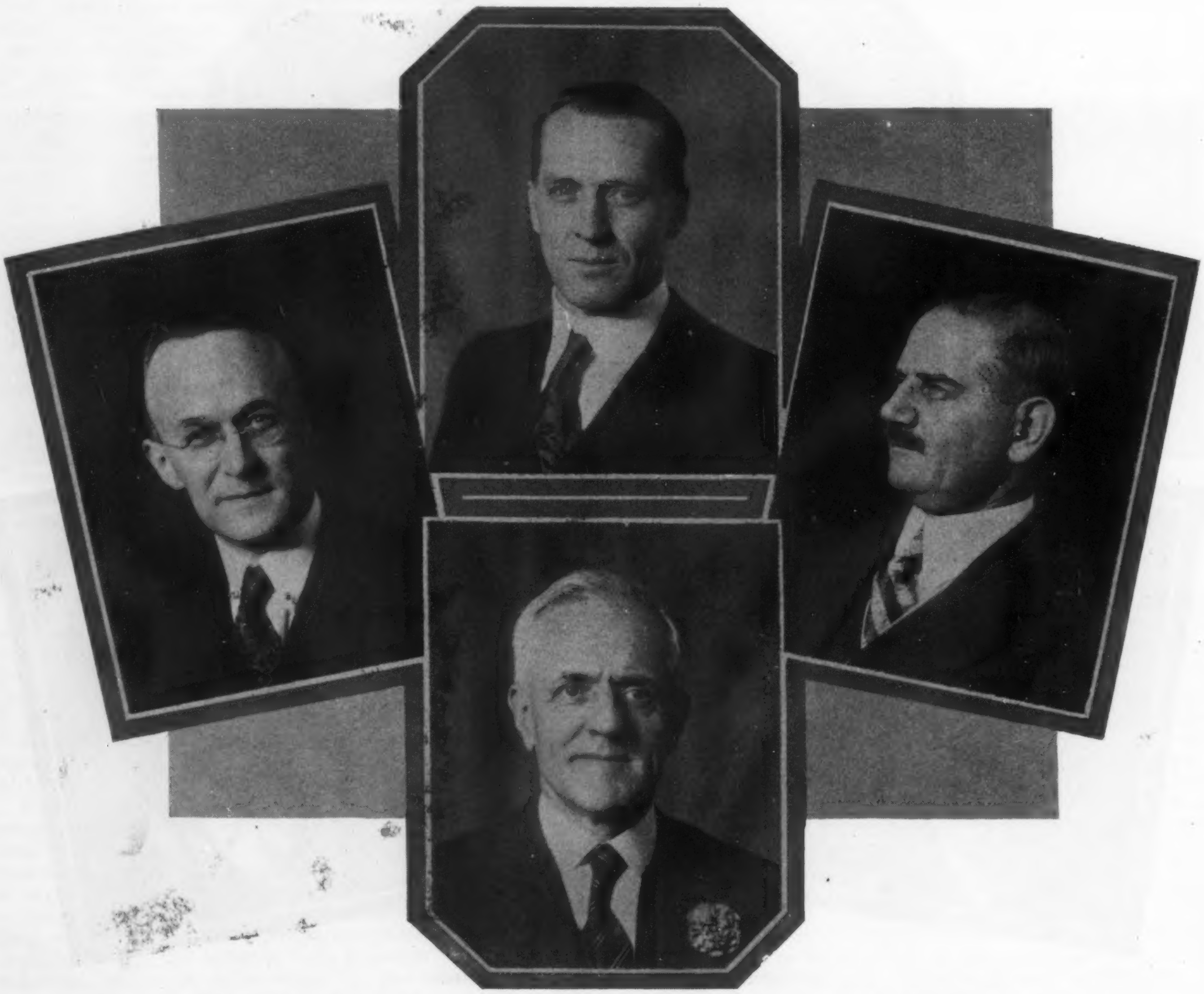
First Joint Meeting of Engineers and Executives Promises Results of Great Value to Industries and the Public

One of the most interesting and important sessions of the Annual Meeting was that on Tire Simplification, Wednesday morning, Jan. 25. The attendance numbered approximately 200.

A general discussion was had of the balloon-tire size situation, based on the report of the Tire and Rim Division of the Society, and the more recent proposal of the Rubber Association of America, Inc., and on the interest expressed officially by the National Automobile Chamber of Commerce.

C. B. Whittelsey, of the Hartford Rubber Works, and the pioneer in the tire standardization work of the Society, having been the first chairman of the Tire and Rim Division, presided. He outlined the procedure to be followed in considering the various proposals and presented statistics to the effect that, in spite of the large number of balloon-tire sizes now manufactured, the bulk of the sales, both for original equipment and replacement business, is confined to six sizes. Reference was made by Mr. Whittelsey to the Tire and Rim Division report, which was printed on p. 127 of the January number of THE JOURNAL. This report was later approved by the Standards Committee at its session in the afternoon, it being recommended for inclusion in the S.A.E. HANDBOOK as a revision of the existing low-pressure-tire rim specifications. This report provides a list of rim sizes adequate for the present and immediate future requirements of car manufacturers.

The National Automobile Chamber of Commerce was



AMONG THOSE WHO TOOK ACTIVE PART IN THE TIRE-SIMPLIFICATION CONFERENCE

C. B. Whittelsey (Lower Center), of the Hartford Rubber Works and Treasurer of the Society, Who Presided at the Tire-Simplification Conference at which a Report on Balloon-Tire Sizes Was Prepared; B. J. Lemon (Upper Center), of the U. S. Rubber Co., Alfred Reeves (Right), General Manager of the National Automobile Chamber of Commerce, and Maurice Olley (Left), of Rolls-Royce of America, Inc., Who Took an Active Part in the Discussion; Roy D. Chapin, President of the Hudson Motor Car Co., and President of the National Automobile Chamber of Commerce; Alvan Macauley, President of the Packard Motor Car Co. and Vice-President of the N. A. C. C.; and Alfred Reeves, Represented the N. A. C. C. at the Conference

represented at the meeting by its President, Roy D. Chapin, Alvan Macauley, vice-president, and Alfred Reeves, general manager. H. M. Crane, chairman of the Tire and Rim Division of the Standards Committee of the Society, explained the work of the Division and the principles that have underlain its procedure. He reviewed the recent history of tire and rim standardization and stated that it was the opinion of the Division that the only features which it can be hoped to standardize are the widths and the diameters of rims, as interchangeability depends on these dimensions. The first attempt to accomplish in the recent past anything in the way of standardization was made at French Lick Springs in May, 1926. He further indicated that the car engineers did not in any way attempt to design the rim, or to control rim dimensions, this being a function of the Tire and Rim Association of America. Likewise, in the original tables, the list of tires indicated was to provide information as to the sizes that would fit the rims specified. No attempt to standardize tire sizes was intended.

Mr. Crane outlined the serious situation arising from constantly changing wheel diameters; which condition contributed largely to the lack of use of the tables of rim sizes heretofore adopted by the Society.

The current proposal of the Tire and Rim Division was an outgrowth of collected data on the present tire sizes used, and information indicating so far as possible what will be required next year. It is based entirely on what has been learned by experience in use of tires. No attempt has been made to design arbitrary standards.

In view of the fact that Mr. Crane believes that a more-stable condition has been reached with reference to wheel diameters, he expressed the opinion that it should be possible to accomplish something more this time than was possible when the subject first came up.

J. E. Hale of the Firestone Tire & Rubber Co., in reviewing the situation, said that the control of standardization of tires is largely in the hands of the motor-car manufacturers. He agreed in general with Mr. Crane's view that standardization can be based only on what has been learned by experience, and said that the Firestone company would support any logical standard recommendations devised by vehicle engineers. He stated his company would back and push a tire simplification movement.

B. J. Lemon of the United States Rubber Co., who has done considerable work recently in connection with tire-standardization matters, advised that the meeting endorse the Tire and Division report in order that it might be presented to the Standards Committee for its approval. He felt that nothing could be accomplished on the balloon-tire simplification plan proposed by the Rubber Association until after it had been considered at the meeting of the executives of the car and tire Companies planned to be held at a later date.

The proposal of the Rubber Associations is as follows:

Proposed Balloon-Tire Simplification Recommended by the Rubber Association of America, Inc.

TABLE 1—PRESENT ORIGINAL EQUIPMENT—24 SIZES

	4.50	4.75	5.00	5.25	5.50	6.00	6.20	6.75
18	....	....	....	28x5.25	28x5.50	30x6.00	30x6.20	30x6.75
19	....	28x4.75	29x5.00	29x5.25	29x5.50	31x6.00	31x6.20	31x6.75
20	....	29x4.75	30x5.00	30x5.25	30x5.50	32x6.00	32x6.20	32x6.75
21	30x4.50	....	....	31x5.25	....	33x6.00	33x6.20	33x6.75

TABLE 2—SUGGESTED SIZE-REDUCTION—FIRST REVISION—16 SIZES

	4.50	4.75	5.00	5.25	5.50	6.00	6.50	7.00
18	....	....	....	x	28x5.50	30x6.00	30x6.50	30x7.00
19	....	28x4.75	29x5.00	x	29x5.50	31x6.00	31x6.50	x
20	....	29x4.75	30x5.00	x	30x5.50	32x6.00	32x6.50	34x7.00
21	30x4.50	....	....	x	....	x	x	x

The first revision eliminates the 5.25 name-size and all 21-in. tires except the 4.50 name-size; also 6.75/10 size.

This can be reduced to an ultimate of the following seven sizes provided the National Automobile Chamber of Commerce will recommend the adoption of one wheel-diameter for all sectional sizes. Greatest tire economy will result from the adoption of the 20-in. wheel diameter.

TABLE 3—SUGGESTED SIZE-REDUCTION—SECOND REVISION—7 SIZES

	4.50	4.75	5.00	5.25	5.50	6.00	6.50	7.00
18	....	....	....	....	x	x	x	x
19	....	x	x	....	x	x	x	....
20	29x4.50	29x4.75	30x5.00	....	30x5.50	32x6.00	32x6.50	34x7.00
21	x	....	....	....	....	....	....	....

DIMENSIONAL DATA ON TIRES AND RIMS FOR SEVEN TIRE SECTIONS IN FIRST AND SECOND REVISION

Rims		Tires			Maximum Load
Flange Height, In.	Width Between Flanges, In.	Name Size, In.	Section Width Commercial Practice, In.	Difference Between Sizes In.	Four-Ply 20-In. Tire at 35 Lb. of Inflation-Pressure, Lb.
0.687	2.75	4.50	4.75	....	800
0.687	2.75	4.75	4.95	0.20	875
0.781	2.75[a]	5.00	5.20	0.25	9.50
0.781	2.75[a]	5.50	5.65	0.45	1100
0.875	3.25[b]	6.00	6.10	0.45	1250
0.875	3.25[b]	6.50	6.55	0.45	1400
0.875	3.75	7.00	7.00	0.45	1550

Rim flanges have not been changed.

[a] The width of the 4-in. rim has been changed from 2.68 to 2.75 in.

[b] The width of the 4½-in. rim has been changed from 3.125 to 3.25 in.

Mr. Lemon outlined the procedure leading up to the formulation of the proposal of the Rubber Association and explained the reasons for including many of the rim sizes, the reasons for proposing the widening of the nominal 4½ and 4-in. rims.

President Chapin, of the National Automobile Chamber of Commerce, assured the meeting of the cooperation of that organization, stating that the problem of the entire standardization requires full measure of cooperation of all industries concerned. He expressed the hope that headway would be made at the meeting and that a recommendation would be formulated from the two proposals under consideration which could be submitted to the executives of motor-car and tire companies, which, as well as the public, are very vitally interested in the matter.

A very representative body of automobile engineers attended the meeting, many of them taking part in the discussion. The great interest being taken in the subject was amply shown by the attendance of many of the foremost engineers in their fields of work.

W. R. Griswold, of the Packard Motor Car Co., outlined the attitude of his company, which was full approval of the work being undertaken. He did not feel capable of commenting on the proposed standard sizes for small cars which are outside of the work of his company.

Considerable interest was evidenced in the remarks of O. E. Hunt, of the Chevrolet Motor Co., who cited the economic problem involved in the reduction of tire sizes. He said: "It is an economic problem to try to reduce tire sizes in the interest of better service to customers and to reduce capital tied up in inventories in the hands of dealers." He pointed out that an intelligent plan is necessary as a foundation, and that full cooperation is needed in order that little differences may be adjusted and a logical conclusion arrived at.

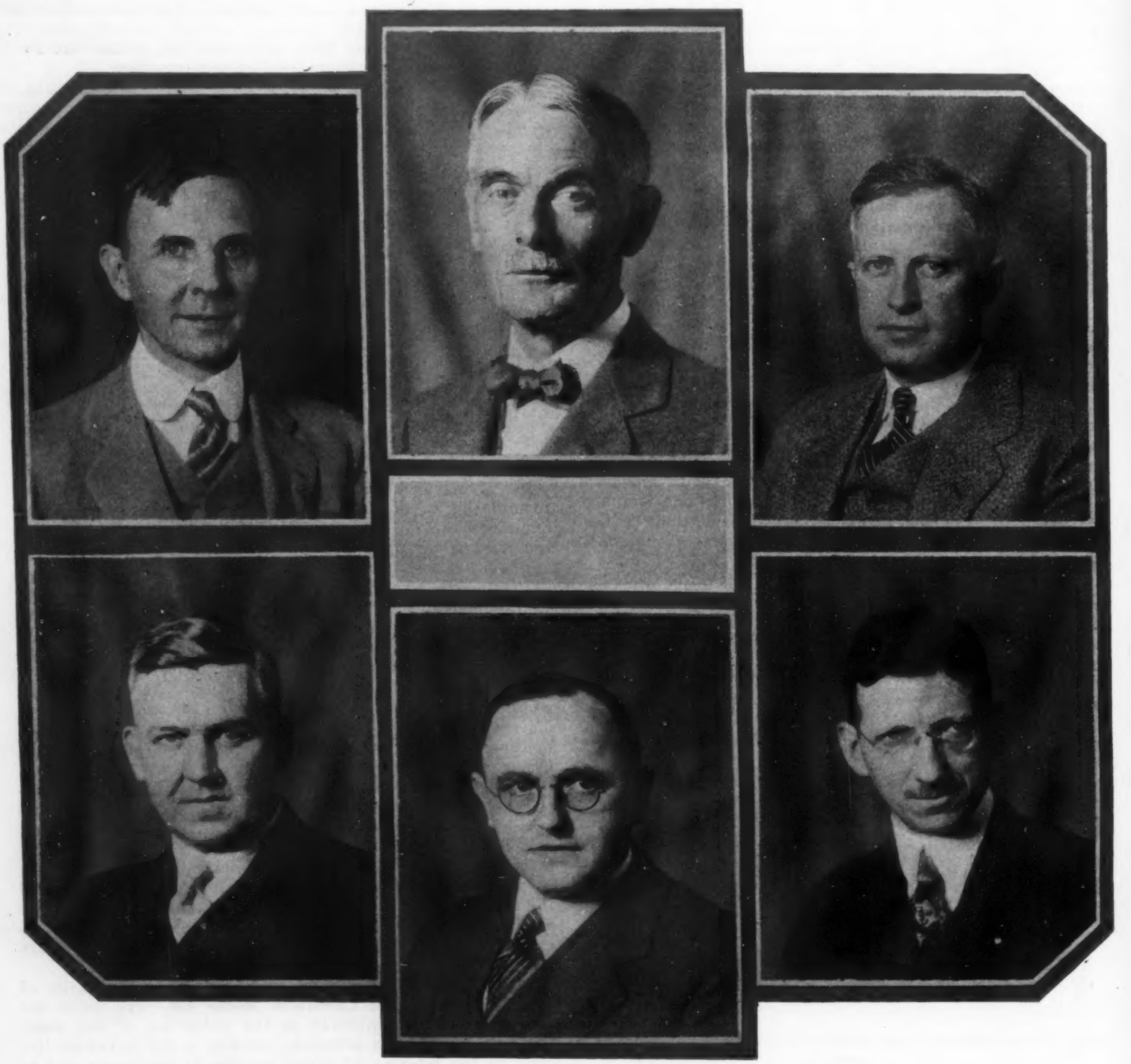
K. L. Herrmann, of the Studebaker Corporation of

America, said that his organization is thoroughly in accord with the work under consideration. He expressed himself as being in favor of including a 20 x 4-in. size in the tables submitted, stating that he believed the usage was sufficient to justify this size. He further placed himself on record as favoring the proposed increase in width of rims as indicated in the Rubber Association's proposal, and cited the fact that some work should be done looking toward the marking of tires to indicate more clearly what size they actually are.

W. T. Fishleigh, of the Ford Motor Co., outlined the reasons underlying the choice of the rim width adopted for the Model-A Ford, calling attention to the difficulties experienced in determining such a dimension because of the drop-center type of rim used. He further assured the meeting of the cooperation of his organization in the work.

F. W. Hentrick, of the Buick Motor Co., questioned the advisability of changing the widths of the 4 and the 4½-in. rims in view of the large number of these rims now in use. He said that his organization is generally in favor of the sizes proposed and offered the cooperation of the company.

F. E. Watts, of the Hupp Motor Car Corporation, doubted the wisdom of even considering the second proposal of the Rubber Assciation (See table 3) reducing tires to seven sizes based on a 20-in. wheel, because, in his opinion, the tendency will be toward small wheels and large tire-sections.



MEMBERS OF THE COMMITTEE APPOINTED TO SIMPLIFY BALLOON-TIRE SIZES

Walter T. Fishleigh (Upper Left), of the Ford Motor Co.; H. M. Crane (Upper Center), of the General Motors Corporation; O. E. Hunt (Upper Right), of the Chevrolet Motor Co.; C. P. Thomas (Lower Left), of the Reo Motor Car Co.; E. S. Marks (Lower Center), of the H. H. Franklin Mfg. Co.; and Karl L. Herrmann (Lower Right), of the Studebaker Corporation of America. The Other Members of the Committee Were A. H. Knight, of Dodge Bros., Inc.; W. R. Griswold, of the Packard Motor Car Co.; L. Thoms, of the Graham-Paige Motor Corporation, and F. E. Watts, of the Hupp Motor Car Corporation

A. H. Knight, of Dodge Bros., Inc., stated that his company is heartily in accord with the program, which will mean real benefit to the manufacturer and to car users. He further expressed favorable opinion of the Tire and Rim Division's proposed recommended practice, and stated that he did not feel that the change in rim width as suggested by the Rubber Association, if made, would in any way materially affect the situation.

The practice of the Cadillac Motor Car Co. with reference to the use of a special wide rim was outlined by G. E. Parker. With respect to size of tires, he said that an increase of 1 in. in wheel diameter, increasing the tire-size, will give approximately 12 per cent more mileage at a cost of about 5 per cent of the entire equipment. He stated that in going to small wheel-diameters a decrease in tire mileage will be noted.

The drop-center rim was introduced into the discussion by Maurice Olley, of the Rolls-Royce of America, Inc. Mr. Olley also raised the question of road clearance as affected by small wheel-diameters and referred to the metric wheel standardization which has been accomplished abroad.

It was the opinion of the majority of those present at the meeting that the report of the Tire and Rim Division should be considered favorably. This was an expression of informal opinion only inasmuch as formal action on the matter was scheduled for discussion at the Standards Committee meeting held at the afternoon session.

At the suggestion of First Vice-President Wall, a special advisory committee was named to consider the proposal of the Rubber Association. The personnel of this committee, as appointed by Chairman Whittelsey, was as follows:

H. M. Crane, *Chairman*	General Motors Corporation
W. T. Fishleigh	Ford Motor Co.
W. R. Griswold	Packard Motor Car Co.
K. L. Herrmann	Studebaker Corporation of America
O. E. Hunt	Chevrolet Motor Co.
A. H. Knight	Dodge Bros., Inc.
E. S. Marks	H. H. Franklin Mfg. Co.
C. Thomas	Reo Motor Car Co.
L. Thoms	Graham-Paige Motor Corporation
F. E. Watts	Hupp Motor Car Corporation

This committee met during the day and submitted the accompanying report which was transmitted to motor-car and tire company executives for their joint consideration. It is understood that the report will be considered next month at a meeting of motor-car and tire company executives.

Report of S.A.E. Special Advisory Committee on Tire Simplification

The advisory committee, appointed to consider the proposal of the Rubber Association of America, Inc., for balloon-tire simplification, herewith submits its unanimous report.

We consider that the simplification proposed in the R. A. A. "second revision," based on 20-in. wheel-diameter only, to be too radical for adoption at this time, especially as it does not conform to present tendencies in the industry toward smaller wheel-diameters than 20 in.

We recommend that the R.A.A. "first revision" table (Table 2 in the Rubber Association's proposal) be revised as follows:

(1) The tire-size designation shall include the tire diameter and section, and the rim diameter

(2) In naming the tire size, the tire diameter should be the wheel diameter plus twice the tire section

(3) The present practice of marking, on the tire, the rim size on which the tire is recommended for use should be continued

(4) The present practice of measuring tire sizes on their respective rim-sections should be continued. This practice is:

4.50 sections 4.75 sections 5.00 sections 5.25 sections 5.50 sections	recommended by R.A.A.; on 4½-in. rim or on 3.25 rim R.A.A.;
6.00 sections 6.50 sections	on 4½-in. rim or on 3.25 rim recommended by R.A.A.;
7.00 sections on 5-in. rim	

(5) In manufacturing practice, the R.A.A. should, in measuring, hold as near as possible to the above-named section-sizes

(6) The 7.00 section on the 18-in. wheel should be dropped and the 5.25 on the 18-in. rim substituted

(7) The 4.75 section on the 20-in. wheel should be dropped and the 5.25 on the 19-in. rim substituted

(8) The rim widths recommended by the R.A.A. are favorably considered but should be given further study by the Tire and Rim Association of America

Adopting the above named recommended changes, the R.A.A. "first revision" table would be as follows:

	4.50	*4.75*	*5.00*	*5.25*	*5.50*	*6.00*	*6.50*	*7.00*
18	....	....	....	28.5x5.25 18	29x5.50 18	30x6.00 18	31x6.50 18	x
19	....	28.5x4.75 19	29x5.00 19	29.5x5.25 19	30x5.50 19	31x6.00 19	32x6.50 19	x
20	....	x	30x5 00 20	x	31x5.50 20	32x6.00 20	33x6.50 20	34x7.00 20
21	30x4.50 21	....	....	x	....	x	x	x

We recommend the adoption of this table.

S.A.E. Special Advisory Committee

H. M. Crane, *Chairman*	General Motors Corporation
W. T. Fishleigh	Ford Motor Co.
W. R. Griswold	Packard Motor Car Co.
K. L. Herrmann	Studebaker Corporation of America
O. E. Hunt	Chevrolet Motor Co.
A. H. Knight	Dodge Bros., Inc.
E. S. Marks	H. H. Franklin Mfg. Co.
C. Thomas	Reo Motor Car Co.
L. Thoms	Graham-Paige Motor Corporation
F. E. Watts	Hupp Motor Car Corporation

Detroit, Jan. 25, 1928.

RESEARCH SESSION HUNTS DETONATION

New Investigations of Fuel Volatility Measurements Also Presented

A search for the seemingly elusive will-o'-the-wisp detonation occupied the major part of the Research Session on Thursday morning, Jan. 26. The remainder of the time was taken in a successful effort to track down that equally important characteristic of motor-fuel, volatility expressed in terms that indicate more readily than does the Engler distillation curve the probable performance of the fuel in the engine.

With S. W. Sparrow as chairman to act as chief guide, those who led the pursuit were H. K. Cummings, of the Bureau of Standards, whose efforts were embodied in a paper entitled Results of a Recent Detonation Survey; Neil MacCoull, of the Texas Co., with his Knock Characteristics of Present-Day Fuels; Dr. Graham Edgar, of

the Ethyl Gasoline Corporation, who joined with A Comparison of Methods of Measuring Knock Characteristics of Fuel; and O. C. Bridgeman, who took the field alone on his particular subject, The Volatility of Gasoline-Air Mixtures.

The session was a high tribute to the value of the Cooperative Fuel-Research which has been carried out jointly by the National Automobile Chamber of Commerce, the American Petroleum Institute and this Society for the last 6 years. Two of the papers, those by Mr. Cummings and Dr. Bridgeman, embodied results of investigations carried out under the direction of the three organizations; two, those by Dr. Edgar and Mr. MacCoull, were brought to the attention of this Society through its membership in the steering committee supervising the project. The two functions of the cooperative undertaking that has joined the interests of the petroleum and the automotive industries and redounded to the interest of both were well typified; the actual performance of fundamental research on topics of current and vital interest and the constituting of a clearing house for information on the investigations carried out by others.

Twenty Methods of Measuring Detonation Described

Mr. Cummings indicated the difficulty that must beset investigators in their efforts to locate exactly the detonation characteristics of motor fuels by his summary of methods now used for this purpose. He presented in a table the salient features of no less than 20 experimental procedures now in operation in various laboratories; five of these were described in his report at the 1927 Annual Meeting, five were modifications of methods covered at that time and again considered in detail in the present treatise, and the remaining 10 have been made known more recently through published information and also are described fully in the current paper. This section of Mr. Cummings' paper represents what is proposed to be a continuing project of the Cooperative Fuel-Research, the maintenance of contact with and the reporting on methods of measuring detonation in use with the object of keeping fluid the technical interest in this subject and tending to prevent standardization on any one procedure until its superiority has been fully demonstrated after a consideration of the merits of all.

Contributing distinctly to the understanding of the complexity of the situation, Mr. MacCoull presented an outline analysis of the methods used in operating engines in determinations of the detonation characteristics of motor fuels. This showed that two ways of controlling the engine from non-detonating to detonating range are being employed; three major types of detonation detection, under one of which two sub-variations are noted; and three separate terms for evaluating results, with two of these being again split up into three subdivisions. A further sidelight was thrown on the variations in method by a diagram in which were pictured the widely different combustion-chamber designs in the engines used for testing purposes.

Results of Detonation Surveys

The chief purposes of both Mr. MacCoull's and Dr. Edgar's papers were to show how antiknock ratings for the same fuels made by different methods compare with one another, to attempt to correlate the results and to indicate what, from their investigations, seem to be the most promising lines of effort for the development of apparatus and procedure for practicable and accurate detonation measurements.

In the investigation reported by Mr. MacCoull each of 10 laboratories tested, by the method it commonly uses, the same six gasolines, which varied widely in antiknock values as well as volatility. Dr. Edgar's survey covered five fuels and nine laboratories. The laboratories were asked, in this latter project, to do two things: first, to determine by whatever methods they were in the habit of using the quantity of tetraethyl lead which must be added to four of the gasolines to make the tendency to knock exactly equal to that of the fifth sample which had been treated with enough tetraethyl lead to make its tendency to knock somewhat less than that of any of the other samples; and second, to rate the gasolines according to any other system they were in the habit of employing.

In general, the results of both surveys seemed to indicate that, while all methods of detonation measurement in common use would, in general, rate fuels in the same order, they would give evaluations varying among themselves to a greater or less degree. To bring out the extent of the variations, Mr. MacCoull tabulated all the results obtained by the 10 laboratories on the six fuels. He then considered the values given by each laboratory for a selected fuel as zero, and those for a second selected fuel as 100 per cent and located all other values in the terms of percentage between these two points. The maximum and minimum percentage values shown by the laboratories for the four remaining fuels were: 97, 23; 66, -47; 144, -10; 500, 109. Amplifying this summary table, Mr. MacCoull not only assembled an impressive array of data, but analyzed it so as clearly to show its import.

An especially significant section of his paper dealt with the comparison of the results obtained with variable-compression engines expressed in terms of the permissible increase of compression ratio and those given by the laboratories using fixed-compression engines and expressing results in the form of manifold vacuum for audible detonation. The average values arrived at by these methods were found to be in very satisfactory agreement. Other interesting material incorporated in the report was a detailed description of a single-cylinder test engine being used in the laboratory of the Texas Co. for antiknock measurements, some results obtained with it as to the effect of mixture-ratio on detonation and a study of the use of several knock-suppressing materials as scales.

Recommendations for Future Development

In concluding his paper, Mr. MacCoull stressed the necessity for further development of antiknock measurements, the immediate standardization of certain points of technique, and an intensive study of the fundamental methods in use for direct control of detonation in test engines. He deprecated the measurement of antiknock values in terms of mixtures of a reference fuel with benzol or tetraethyl lead. Finally he expressed the belief that when a standard scale is adopted for measuring antiknock values, it should have some direct connection with compression ratio. It seemed probable, he said, that if all laboratories measure antiknock values in terms of per cent change in compression ratio for variable-compression engines or manifold vacuum for the usual engines the data taken on any engine might be related to that of any other by the simple use of a single multiplying constant.

Dr. Edgar concluded from his tests, which were reported in full in the January issue of The Journal, that considerable divergence is to be expected from the results of different methods of testing fuels and that the various scales for rating fuels used at present cannot be interpreted readily among different laboratories. In his opinion, rating fuels in terms of two pure hydrocarbons, preferably as nearly alike as possible in their physical properties, should go far toward solving this problem. He also referred to the bouncing-pin method of determining the equality of knock of two fuels as one that seemed, from the tests made, to be reasonably satisfactory.

Material not only on methods of measuring detonation but on the antiknock characteristics of current fuels was presented at the Research Session. This was embodied in the second section of Mr. Cummings' paper, which reported two surveys conducted in the course of the Cooperative Fuel-Research, one of gasolines available at refineries, the other of average fuels available to motorists in different

sections of the Country. The samples tested in the first class ranged from 11 per cent worse to 30 per cent better than the reference fuel. The values found in the second survey seemed to indicate that north of Texas and east of the Rockies the average detonating value of fuels sold at filling stations and garages would not vary greatly in the different geographical sections of the Country. The Texas sample showed a slight and the California sample a considerable improvement over this general dead level.

Automotive Industry Gets Volatility Yardstick

The accomplishment achieved by Dr. Bridgeman in his paper was, briefly, to put into the hands of the automotive industry a yardstick for the measurement of gasoline volatility in terms of engine performance. The American Society for Testing Materials distillation method is open to objection by the motor-car manufacturer since it does not tell him the particular thing he wants to know: How much fuel must be supplied to get a certain mixture-ratio at a certain definite temperature? The equilibrium air-distillation methods that were developed seemed to promise to give that result, but they were new and not so generally known as the one which had been followed. The analysis reported by Dr. Bridgeman furnishes a table of conversion factors which makes the use of the old method entirely feasible and gives the information the automotive engineer particularly desires.

During the discussion, H. M. Crane and H. L. Horning stressed the contribution made by the Cooperative Fuel-Research to progress both in the automotive and the petroleum industries; and J. H. Geisse, of the Naval Aircraft Factory; H. M. Jacklin, of Purdue University; G. G. Brown, of the University of Michigan; and others told of their experiences in the field of antiknock measurements.

Speakers at the Morning Research Session

S. W. Sparrow (Center), of the Studebaker Corporation of America, Who Presided; Dr. Graham Edgar (Upper Left), of the Ethyl Gasoline Corporation, Who Presented a Paper on Comparison of Methods of Measuring Antiknock Characteristics of Fuel, Which Was Published in the January Issue of The Journal; Neil MacCoull (Upper Right), of the Texas Co., Who Presented a Paper on Methods of Measuring Detonation; H. K. Cummings (Lower Left), of the Bureau of Standards, Who Presented the Results of Two Detonation Surveys; and O. C. Bridgeman (Lower Right), of the Bureau of Standards, Who Presented a Paper on Volatility Data from Gasoline Distillation Curves

RESEARCH PROBLEMS YIELD TO SCIENCE

High-Speed Motion Analyzed and Measured; Headlighting and Oil Studied

Convincing demonstrations of the advances science has made in the development of instruments for the exploration of regions that, by their inaccessibility, hitherto have baffled human curiosity were made at the Research Session held on the afternoon of Jan. 26. In addition, the papers presented embodied the results as well as the methods of carefully achieved research on subjects of current interest.

The program contains the skeleton of the session, the following list of papers and authors: Low-Temperature Characteristics of Motor Oils in Relation to Their Performance, by R. E. Wilkin, P. T. Oak and D. P. Barnard, 4th, of the Standard Oil Co. of Indiana; Recent Developments in Headlighting Research, by H. H. Allen, of the Bureau of Standards; Further Data on Riding-Qualities, by R. W. Brown, of the Firestone Tire & Rubber Co.; and the Application of the High-Speed Motion-Pictures to Engineering Development, by C. Francis Jenkins, of the Jenkins Laboratories. It is more difficult, almost impossible, to frame into words the vitalized and well-rounded spirit of the meeting, contributed to by the actual presence of the apparatus described, the informal comments of the authors emphasizing and bringing home in man-to-man fashion the points of their papers, the quick exchange of ideas and of question and answer in the discussion, and the intensified vividness of interest that comes when the attention of many auditors is held to one subject.

Solenoid Damps Accelerometer Chatter

John Warner, of the Studebaker Corporation of America, who because of his wide acquaintanceship in the Society and his suave personality is well qualified to act as host, was chairman of the meeting. Mr. Brown, the first speaker, aroused unusual interest by his description of an instrument for the study of riding-qualities that by actual demonstration is known to have reached the point of development where it can be relied upon to make dependable measurements. The instrument described and shown consists of six accelerometer elements, each element being connected with a separate counter. Hence, at the end of a run the number of accelerations occurring between six predetermined values can be read directly from the counters. The use of a recorder or an integrating device was discarded in favor of a counter for reasons given. A notable feature of the accelerometer elements, which are of the contact type, is the replacement of the spring or air pressure with a solenoid, resulting in the elimination of contact chatter. An especially sensitive counter was also developed for the construction of the instrument.

The application of the instrument to the study of riding-qualities of tires was shown by Mr. Brown, and its use in a number of situations where vibrations and accelerations are to be measured was suggested in the discussion.

Leading up to the introduction of the next speaker, Mr. Brown exhibited a slow-motion picture to illustrate what happens when a tire passes over an obstruction. Clearly distinguishable lines drawn on the side walls of the tires from tread to rim, at fairly close intervals, enabled the eye to follow closely the distortion when the cleat was encountered. The pneumatics could be seen to wrap themselves around the obstructions. The bounding action of the solids after passing over the bump was also caught and recorded by the high-speed camera.

With the exhibits shown by the next speaker, Dr. Jenkins, the audience received a real revelation of the manner in which high-speed motion can be broken-down into its component parts by photographic analysis. Dr. Jenkins was introduced as the farm boy who developed into a scientist, who produced the first photographs by radio and mechanism for viewing distant scenes by radio, who has more than 300 patents and who, finally, brought from an idea into concrete, practical operating existence the chronoteine or time-stretching camera. The detail construction of the camera and the long extended efforts of its inventor in perfecting it are set forth in Dr. Jenkins' paper published in THE JOURNAL. The distinguishing feature of its design is that the lenses and film move continuously and the shutter stands still, of its results that they picture the rate of action at 1/200 of the speed of the original motion, or 1/20 the rate of the slowest common or garden slow-motion movies.

Dr. Jenkins brought home a realization of the gap that exists between the two types of slow-motion camera in his studies of the subjects commonly pictured, hurdle jumping on horseback, golf strokes, ball pitching, diving, and pole vaulting. The startling effect of the apparent delay in the action of gravity in the jumping and diving, and the amazing complexity and intricate detail of movement were sufficient to hold the attention of the audience, but no less a word than thrilling could be applied to the climax of Dr. Jenkins' exhibition, pictures of pigeons rising from the ground in flight. They distinguished the alternate forward and back movement of the wings, each of which aids the bird in its aerial travel, and the sweeping flexion, resembling the dancer's graceful waving of a Spanish shawl, of the outer half of the wing, which, to the naked eye, appears rigid.

H. L. Horning piquantly summed up the service that such a camera could perform for engineering. "All the laws of the prophets were written around that peculiarity that every dog has its day, every cat its afternoon and everything its period," he said. The camera will detect these destructive periods, the vibrations that are set up in even seemingly rigid parts, enable the engineer to study them with a view to eliminating them, and thus achieve, without concomitant disadvantages, the high speeds toward which mechanisms are tending.

Following the discussion of Dr. Jenkins' paper, during which were brought out many additional facts concerning its design and construction, H. Billioque, of Musa-Hartzell-Ducasse, Inc., described briefly the Stroborama, a stroboscope built by Seguin Bros., of France, makers of the Gnome aviation engine. This apparatus was on view in the hotel, and many members who saw it demonstrated remarked on its distinctive feature, an illumination of 1000 cp. spread over a large surface so that an entire engine or even an entire car may be included in the lighted area. The intensity of the illumination makes possible the taking of observations without darkening the room. In his demonstrations Mr. Billioque slowed down the action of a valve-spring, so that the surge could be definitely seen, and, to the eye at least, entirely arrested the vibration of a string so that it appeared as a succession of stationary sinucoidal waves.

Headlight and Oil Study Reported

Mr. Wilkin presented the paper prepared by him, Mr. Oak and Mr. Barnard. This report on an investigation of considerable timely interest, Motor-Oil Characteristics and Performance at Low Temperatures, may be read in full in THE JOURNAL. Briefly, the conclusions arrived at were that: to be ideal for low-temperature operation a motor oil should have a low temperature-coefficient of viscosity and low pour-test; cranking characteristics evidently are dominated by viscosities at fairly high shearing-stresses and can be predicted satisfactorily by extrapolating inspection data on Herschel's chart; those oils in which the deviation from the laws of viscous flow is great appear at a disadvantage for automobile-engine work, due to their relatively poor circulating characteristics; and since oils do not generally have both low temperature-coefficients of viscosity and low pour-tests, the former characteristic should be

SPEAKERS AT THE AFTERNOON RESEARCH SESSION

J. A. C. Warner (Center), of the Studebaker Corporation of America, Who Presided; Dr. C. Francis Jenkins (Right Center), Who Discussed Slow-Motion Pictures; R. E. Wilkin (Upper Right), and D. P. Barnard, 4th (Left Center), of the Standard Oil Co. of Indiana, Who Discussed Motor-Oil Characteristics and Performance at Low Temperatures; H. H. Allen (Upper Left), of the Bureau of Standards, Who Reported on Recent Developments in Headlighting; R. W. Brown (Lower Left), of the Firestone Tire & Rubber Co., Who Discussed the Measuring of Riding-Qualities; and Dr. H. C. Dickinson (Lower Right), of the Bureau of Standards, Chairman of the S.A.E. Research Committee

emphasized and the effect of the latter eliminated or minimized by enlarging pump inlets.

Mr. Allen's paper, the last on the program, embodied fundamental data on the subject of headlighting, and Mr. Warner added humor to the scientific interest of the report by referring to the arduous conditions under which the investigation was carried out, all the observations necessarily being taken at night and in territory removed from the beaten track of traffic.

The paper is a progress report on a headlight investigation being carried out at the Bureau of Standards under the technical direction of the Research Committee of the Society with funds provided by the National Automobile Chamber of Commerce. The object of the investigation is to ascertain by means of road tests, supplemented by laboratory experiments, what the headlight requirements of the driver are under various conditions and how best to fulfill these requirements under these conditions. The data collected in Part 1 of the program, observations made in the absence of approaching light and as nearly as possible under the same environmental conditions, were sufficiently complete to be included in this report. The results obtained indicate the effect on visibility of the speed of the car; the size, shape, color and other characteristics of the object observed; variation in the amount of moonlight; light-source intensity; and the tilt and horizontal and vertical spread of the beam.

Work is now in progress on Part 2, which consists of observations made alternately with and without approaching lights, with environmental conditions as widely divergent as are likely to be met under ordinary driving conditions. In the paper the apparatus and procedure for this more complex section of the investigation were described, and the program outlined. This contemplates, among other items, observations with light intensities considerably above 21 cp., the study of unsymmetrical lighting distributions and the photographing of representative beam patterns on a standard screen for purposes of correlating the results obtained.

Independent Front Springing Proposed

Front Suspension and Shimmy, Shock Absorbers and Brakes Are Discussed at the Chassis Session

Friday afternoon came the Chassis Session, at which W. R. Strickland, assistant engineer of the Cadillac Motor Car Co. presided. The first paper, written by D. Sensaud de Lavaud, of Paris, France, upon Independently Sprung Front Wheels as a Remedy for Shimmy, was presented by the chairman, who read extracts from it.

In the paper, the conventional front suspension of automobiles is characterized as a deplorable survival of horse-drawn-vehicle days. It is so unsatisfactory mechanically that it should have been only a memory long ago; but the inconveniences resulting from it have not been attributed to their real cause, according to Monsieur de Lavaud, and palliatives have been applied instead of a remedy.

Critical analysis of the various phenomena is arduous and delicate, and the paper is confined to general ideas of the origins of the phenomena and the conclusions of many experiments made by the author. The theoretical proofs have been reviewed in two communications made by the author to the French Academy of Sciences.

The essential difficulty of the usual system is that it allows the rotating wheels to cause violent gyroscopic effects that may become dangerous by reason of resonance, causing wobble or shimmy or vibrational instability.

Distinct oscillation of the front wheels between the springs and the tires around a longitudinal axis, accompanied by a conjugate flapping motion on their pivots, is the primary phenomenon. This is sometimes violent enough to cause alternate bouncing of the front wheels and is accompanied with other movements of the axle and rolling, pitching and galloping of the chassis. These movements are secondary.

In the usual construction wheels are free to oscillate with the axle as a whole, as well as about their own pivots. The analysis of the motions is quite complicated, involving the following three gyroscopic couples: (*a*) deviation of the axle produces conjugated precessions of the front wheels around their knuckle pivots; (*b*) deviation resulting from this common precession results in a resisting couple opposing oscillation of the axle; and (*c*) the third deviation resulting from the gyrations of the vehicle as a whole in its zigzag movement gives rise to a gyroscopic couple acting on the axle.

The first two of these couples apparently are proportionate to the speed but really are proportionate to the displacement and they cause an interchange of energy between the wheels and axle. The third couple can not only destroy the damping effect but provoke excitation and clearly explains the abnormal vibration that is not accounted for by hypotheses of resonance.

Damping and Friction Are Not the Same

Shock absorbers of the hydraulic type are much preferred by Monsieur de Lavaud to those of the friction type because of the increased resistance of the former at greater amplitudes and velocities. The friction of the latter may not be sufficient under extreme conditions, merely serving to make objectionable phenomena less likely. A distinction should be clearly drawn between damping and friction.

Whereas rigid and irreversible steering-gears are preferable with high-pressure tires, low pressure-tires alter the conditions so that reversibility and elasticity are desirable in the steering-gear to avoid synchronism. It is interesting to note that cars built without differentials are subject to neither shimmy nor wobble. Independent springing of the front wheels is said by Monsieur de Lavaud to be the only specific remedy. A remarkable degree of steadiness and roadibility has been observed in front-wheel-drive cars and this should be credited to the independent springing which usually is one of their features. A car built by the author has a front axle pivoted to the front end of the frame with a large friction-disc. The steering knuckles are mounted to allow a sliding action in a nearly vertical line at the ends of this axle, rubber pads between steel washers taking the place of the usual front springs.

Following his presentation of the paper, Chairman Strickland presented some comments of his own. He praised the analysis of the subject by the author but deprecated his condemnation of the present construction, which has proved itself dependable, while independently sprung wheels might not be so satisfactory in that respect. Road conditions in Europe and America are different, particularly the joints in American concrete roads, which cause the small oscillations. The chairman looked upon shimmy as a solved problem, particularly in cases where shock absorbers are used.

Analysis Confirmed by Tests

Confirmation of the author's conclusions were given by C. R. Paton, of the Studebaker Corporation of America, as the result of tests on a chassis dynamometer with wood lagging on the drums. Study with a stroboscope confirms the theories of gyroscopic action except that the movements do not seem to be perfectly in phase, probably due to a

lag introduced by friction. These experiments have shown that shimmy will occur in a car at a speed that corresponds with the natural frequency of the frame and the body.

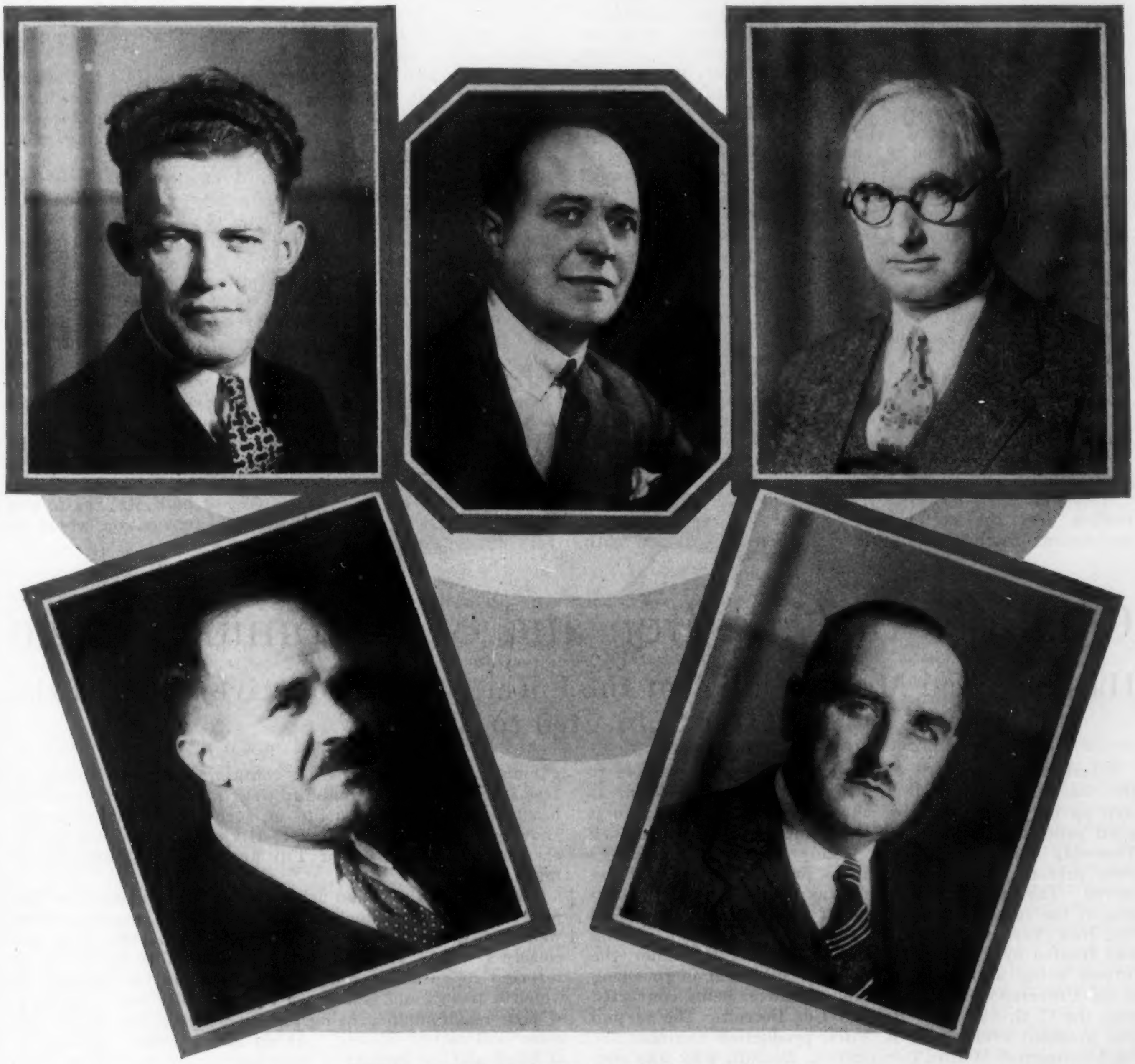
Discussion contributed by E. Zap agreed with the analytical considerations of the paper, but did not approve of its solution. A yielding member of certain characteristics, interposed in the steering linkage, is likely to be a simpler and better solution.

Agreement with the analysis of the paper was also registered in a contribution read by G. E. A. Hallet, head of the powerplant section of the General Motors Research Laboratories, and prepared with the assistance of L. W. Shutts. However, they did not think it necessary to split up the phenomena into so many elements, since all the major disturbance can be traced to the gyroscopic interrelation between shimmy and tramp. Their experiments have shown that neither shimmy nor tramp would occur if one is prevented, as by locking the steering knuckles against turning. They believe that the only reason that the rear axle does not tramp is because it cannot shimmy.

Walter C. Keys, of the U. S. Rubber Co., expressed the hope of trying out the car described in the paper, but he thought that its construction is considerably more expensive than the conventional spring construction. A watertight boot for the telescopic pivot presents difficulties. The use of rubber in place of a spring is desirable because of its ability to dissipate energy.

How Shock Absorbers Are Selected

Following the discussion of Monsieur de Lavaud's paper, N. F. Hadley, of the Chrysler Corporation, presented his paper on Shock-Absorbers from the Car Manufacturer's



Some of the Celebrities at the Chassis Session

D. Sensaud de Lavaud (Center), Whose Paper on Independently Sprung Front Wheels as a Remedy for Shimmy, Improvement of Suspension and Steering Was Presented by W. R. Strickland (Upper Right), of the Cadillac Motor Car Co., Who Presided at the Session; John Sneed (Upper Left), of the Midland Steel Products Co., Who Presented a Paper on Self-Energizing Brakes; and George L. McCain (Lower Left), of Dodge Bros., Inc.; and Edwin Zap, of the Chrysler Corporation, Who Took Part in the Discussion. N. F. Hadley's Paper on Shock-Absorbers from the Car-Manufacturer's Standpoint Was Also Presented at This Session. Mr. Strickland Is First Vice-President of the Society

Viewpoint, saying that shock-absorbers have become of more general interest to the car manufacturer year after year until he now considers them an integral part of the chassis, but no element of automotive equipment is more difficult to evaluate, because satisfactory performance is a matter of individual opinion.

No mathematical analysis of the problem is attempted, but the author outlines his estimate of an ideal shock-absorber and tells how existing equipment measures against this ideal. A shock-absorber is required to dissipate the energy of vehicle springs in excess of that required for the return to normal position, and to help in the elimination of shimmy.

Alleged new shock-absorbers are submitted in such numbers as to make it necessary to develop a machine to help in the process of elimination. This machine resembles a steam-engine indicator for measuring the energy required to move a shock-absorber through its cycle at varying speeds, and it is used in conjunction with road work that has made possible general conclusions regarding the desirable shape of the diagram. The method of investigation includes a desk analysis, charts made on the testing machine, and road tests when found desirable.

Of the two general classes of shock-absorbers, the one-way type is objectionable because the rewind spring has a stiffening effect on the suspension and it has no control over the compression stroke, which seems to be needed because reduced spring-clearance and light springs allow the body to bump the axle on bad roads. Of the frictional one-way devices, those in which the resistance decreases from the beginning to the end of the rebound are considered most desirable.

Hydraulic shock-absorbers in general are objectionable, according to the paper, because of the varying viscosity in the available fluids. The variation of resistance in proportion to the square of the velocity is good for large movements of the car body but is a disadvantage on a cobblestone pavement. Leakage and air admixture are common defects. The one-way hydraulic instrument seems less liable to noise than the frictional type and to have greater dependability and smoother action.

Two-way shock-absorbers should offer little resistance to motion near the normal spring position and increasing resistance at other positions. This can be obtained with hydraulic or friction type instruments, but Mr. Hadley believes that the greatest possibilities for future development lie in the cam-actuated type of two-way mechanical friction shock-absorber.

The Latest Type of Brake

As no one seemed ready to take issue with Mr. Hadley's conclusions on shock-absorbers, John Sneed, of the Midland Steel Products Co., presented his paper on Self-Energizing Brakes. According to him, a brake-shoe should be designed to operate perfectly with a brake-drum that is not perfectly circular. A high degree of self-energization is desirable because it allows liberal clearance and low pedal-effort at the same time.

Operation of Steeldraulic brakes is through a cable control in which the cable is surrounded by a flexible compression element that can be changed in curvature without affecting the tension of the cable. The conduit consists of steel vertebrae surrounded by a close-coiled wire spring and a waterproof boot.

Toggle action is used to expand the flexible brake-band with rigid ends. Brake-lining having a frictional coefficient of about 0.4 is said to give the best results. The foot pressure is not sufficient to secure satisfactory braking effect, and self-energizing is employed.

Replying to a question in the discussion, Mr. Sneed said that he has been unable to find a woven brake-lining with the uniform friction coefficient that is necessary with a self-energized brake. The molded material absorbs much less water.

There was some discussion of servicing, including the difficulty that has been found because of the variation in friction coefficient of different types of lining. C. P. Grimes said that he finds it necessary to carry five different kinds of brake-lining to furnish a satisfactory lining for every car, at his service station in Syracuse, N. Y. Another speaker proposed the standardization of the coefficient of friction for brake lining, but A. J. Scaife, of the White Motor Co., said that different coefficients of friction are desirable for different types of brakes. Greater durability is secured in mechanical operation with hard lining. Lubrication was spoken of as desirable, but both Mr. Scaife and other speakers said that dependable lubrication would be very difficult.

Qualities of Cast Iron and of Chromium Plate

Hardness and Machinability of the Former and Protective Value of the Latter Subjected to Analysis

Interest was centered on the data presented relative to the machinability and wearing qualities of cast iron, as well as on the qualities of chromium plate which give it good protective value, at the Production Session held on Thursday evening, Jan. 26. Many production engineers were present and the two papers presented were well received. The paper on cast iron was by Thomas H. Wickenden, of the research department of the International Nickel Co., New York City, and the subject of chromium plating was treated by Edwin M. Baker and Walter L. Pinner, the former being assistant professor of chemical engineering at the University of Michigan and the latter being connected with the C. G. Spring & Bumper Co., Detroit. The session was presided over by A. R. Fors, production engineer for the Continental Motors Corporation, Detroit, who was successful in inducing numerous members of the audience to take part in the discussion. Opportunity for good fellowship was afforded at the buffet supper served after the session was adjourned.

Mr. Wickenden said that the hardness of an iron is, by itself, no indication of the wearing property and machinability of the iron. Irons containing a large amount of free ferrite have been found to wear rapidly, whereas others having considerable pearlite or sorbite in their structure show good wearing properties. His paper is printed in full elsewhere in this issue of The Journal, and reference is made thereto.

Replying to a question asked during the discussion of the paper as to the relation of the three factors, machinability, wear and kind of finish, Mr. Wickenden said that they are closely related. He defined the machinability to which he referred as meaning a reasonably machinable casting on which a tool would last for a considerable time, a casting of poor machinability being one on which a tool would become dull rather rapidly. As an instance that the degree of finish and the amount of wear are closely related, he compared the former cylinder-blocks which had a reamed finish with those of the present which have a highly polished surface, saying that the present cylinder-blocks unquestionably have better wearing qualities.

The opinion was forcefully expressed by one discusser of the paper to the effect that the subject of wearing-quality

SPEAKERS AT THE PRODUCTION SESSION

A. R. Fors (Upper Center), of the Continental Motors Corporation, Who Presided at the Production Session; E. M. Baker (Upper Left), of the University of Michigan, and Walter L. Pinner (Lower Right), of the C. G. Spring & Bumper Co., Who Presented a Joint Paper on the Protective Value of Chromium Plating; Thomas H. Wickenden (Upper Right), of the International Nickel Co., Who Presented a Paper on Research on the Hardness and Machinability of Cast-Iron; and E. P. Blanchard (Lower Left), of the Bullard Machine Tool Co., Who Outlined the Activities of the Production Advisory Committee

is much more closely related to proper lubrication than it is to the composition of the materials. He considers lubrication much more important than the characteristics of the iron. He advocated, however, that if certainty is desired as to the machinability, a standard machinability-test for metals should be developed. This led to rather detailed statements from several others as to what the present practices are in determining machinability.

Protective Value of Chromium Plate

In the electroplating field, no subject has created more widespread interest than has the deposition of chromium, according to the paper by Messrs. Baker and Pinner. The subject is of particular interest to the automotive engineer, who is employing chromium for two somewhat different purposes. One of these is the coating of surfaces to resist wear. The other is the electrodeposition of chromium for decorative and for protective purposes. The thickness of the deposits suitable for these two purposes is so widely different as to justify separate consideration of them. The paper was therefore restricted in scope to a study of the rust resistance afforded by electrodeposited coatings of chromium alone and in combination with nickel and copper.

It was stated by the authors that the appearance value of a chromium surface is well established, but that chromium alone has little protective value against outdoor exposure. The protective value of a composite coating depends largely upon the protection afforded by the underlying coats. Increase in the amount of chromium deposited on nickel and copper, up to a thickness of 0.00001 to 0.00002 in., increases the protective value, but a further increase of thickness up to 0.00027 in. of chromium decreases the protective value to almost the result obtained with no chromium. These conclusions were supported by tabular and graphic data presented in the paper, and indicate the proper procedures to obtain maximum protective value at minimum cost.

Asked during the discussion of the paper what buffing methods were used before plating with chromium, and what kind of polishing compound, Mr. Pinner replied that he has found little difference in the rust resistance obtained with different kinds of buffing wheel and of polishing compound. Regarding the finishing, he said that unpolished surfaces do not have as good rust-resistance as polished surfaces have.

In response to a question relative to the amount of

chromium plate that can be used without causing the copper and the nickel plating to peel, Mr. Baker said that if the steel base is cleaned properly, is free from oxidation, and the plating is done under proper conditions, there should be no difficulty in obtaining adherent plating which the chromium will not raise.

Numerous questions were asked and answered relative to details of experience with chromium-plated gages and tools, and comparisons were made between the results obtained from salt-spray and other tests for rust-resistance and those obtained from exposure to weather.

Development of Production Activities

As stated by E. P. Blanchard, of the Bullard Machine Tool Co., during the course of the session, a conference of the Production Advisory Committee was held earlier in the evening with regard to stimulating greater activity in the Production Division of the Society. Under the new plan outlined, it is expected that the Society will be enabled to cover the production field more completely for the benefit of the production engineers and to make more complete reports. Some of the phases of production engineering discussed at the conference were material handling and control of processes and equipment, the study of costs from the viewpoint of the production engineer, time study and methods, the bringing uptodate and taking advantage of production standards, the standardization of machine-tool elements and the promotion of closer cooperation between the production engineers and the designing engineers. The expectation is for greater activity and greater interest on the part of the production engineers, and for better and more widespread opportunities for them to take part in the work. To this end it is desired that the production engineers state what their problems are and discuss them, utilizing the means provided, such as the presentation of papers at Section and other meetings, so that methods and standards developed in the individual plants can be made a part of the industrial activities of the Society.

Automotive Industry Told To "Style-Up"

Artistic Design, Style and Color of Automobile Bodies Presented as Conclusive Selling Points

Creative factors that should exert a strong influence on the design of automobile bodies, as well as the use of lacquer finishes to complete the product and enhance its attractiveness, were the subjects ably presented at the Body Session held on Friday evening, Jan. 27. The session may be said to have been analogous to the so-called "whip" with which O. Henry concluded his famous short stories in that it rounded up, in a snappy climax to the 1928 Annual Meeting, all the intangible and inspirational factors of creative and artistic design and showed how they can be correlated with the tangible details of constructive engineering with which the other sessions of the meeting had been concerned.

The address on the Use of Design and Style as a Selling Point was delivered by Richard M. Bach, associate in industrial arts, Metropolitan Museum of Art, New York City. Dr. G. C. Given, of the E. I. duPont deNemours & Co., Wilmington, Del., presented the paper on Automobile Lacquers. Each of the presentations possessed distinctive appeal, and both were enthusiastically received by the 150 or more members and guests in attendance. Following the session, a buffet supper was served during which many expressions of approval of the messages conveyed by Mr. Bach and Dr. Given were voiced.

In the course of his opening remarks as chairman of the session, L. C. Hill remarked that it is a fact that the automobile-body designers of today are responsible for that thing which primarily makes an automobile salable. It is also a fact, he stated, that there is beginning to be applied to the design of automobile bodies more and more of what may be called pure art. The significance of this was borne out, he said, by the further fact that a representative of the Metropolitan Museum of Art had been invited to be the first speaker of the evening. He then introduced Mr. Bach.

One of the first points made by Mr. Bach was that one good way of anticipating the customer on the side of design is always to watch his past preferences, but he said also that out of that must be constructed a prophecy which will be, the designer hopes, the customer's future preferences. Body designers are not alone in that, since there are some 80 or more industries in which artistic design plays a part, and they are all fighting the same battle, anticipating that customer.

Mr. Bach construes business profit as being of two kinds; the kind that is immediate and causes that pleasant tinkle in the cash register, and the kind which causes that tinkle to be repeated without any great outlay of effort. Those two kinds of profit may be compared and contrasted in the business journals as much as seems desirable but, in the

On the Road to Quebec—Where the 1928 Summer Meeting Will Be Held

end, they come to the same thing; namely, the satisfied customer who stays satisfied and comes back. To be sure, said Mr. Bach, you may say he comes back because the car runs and serves as a good conveyance. No, there are lots of cars that run and serve as good conveyances. There are a good many other considerations that enter into design as a selling point. What some of those are you can find in any automobile show, and what some of those have still to be you can also find in any automobile show.

If you get at the thing creatively, the speaker continued, you will see all the materials simply as things to handle, things to which to apply your skill, but always with an objective which will be appreciation, pleasing not only to you but to myriads of others who will point to it as it goes along. You cannot tell at a distance how well the car is running. The fellow inside it knows that. The question is: How does it *look?* One may say that this is dealing in externals, but, if those are treated right, they are integral with the whole construction. An artist is not interested intuitively in a great many things that are technological and purely practical, and he gets results by a curious process of observation which artists somehow have, whereby the artistic mind acts as a crucible in which many ideas are melted down so that we may get the most precious ones.

Invariably discovery and invention constitute the first step, Mr. Bach continued, trade follows next with the usual technical advances and after that comes art, but let us call it style. The consumer's opinion of style is the important thing for body designers to bear in mind. The increasingly skilled preferences in style on the part of the public are the things which must be reckoned with. Build up the design not out of past preferences but out of past rejections. Find out why certain types have not sold. It is not simply the four wheels and the engine which make the thing go, it is the appearance which finally does that. There is, then, this sales side which represents a terrific power that may make or break what the body designer is trying to accomplish. Unless the product is properly presented from the design side, its progress will be hampered or may be turned into a retrogression.

In conclusion, Mr. Bach said that if body designers will just burn the words "style up" into their minds when they get to work on design, they will not for a minute misunderstand what the public wants. Mentally, the public is styling up all the time and is asking every industry to meet its demands in that way.

DR. G. C. GIVEN
of E. I. duPont deNemours & Co., Whose Paper on Automobile Lacquers Was Presented at the Body Session

AUTOMOBILE LACQUERS

In treating his subject, Dr. Given outlined the advances that have been made in body painting since pyroxylin lacquers were first used on a production basis on automobiles in 1923. He then gave definitions of the technical terms used, such as pyroxylin, plasticizer, resin, pigment, solvent, and non-solvent or diluent, passing then to a discussion of the qualities of lacquer which are of special interest to finishers.

To be considered durable, said Dr. Given, a finish should not change color, it should not crack or craze, it should not check off or take on the appearance of an alligator's skin, it should not peel, it should not scratch readily, and it should protect the surface underlying the finish from the action of the elements. These qualities of durability are all influenced by the quality of the lacquer. Among the other items of interest to finishers he discussed also the working properties of lacquers, the number of coats needed, the time required for drying between coats, the smoothness of the final finish, ease of polishing and ease of repairing or touching-up the finish. He said that "pull outs" are frequently encountered in polishing and that these are small comet-shaped blemishes on the finish which are caused by some particle of foreign substance being pulled out of the film by the polishing pad.

"Mist coating" was specified by Dr. Given as being one of the advantageous practices in body finishing. After the "orange peel" has been removed by the sanding operation, there will always be left the small scratch lines of sandpaper. These can all be removed by sufficient work with rubbing compound, but a large portion of this hard rubbing can be avoided by using a "mist coat." This consists in applying a very wet coat of a high-grade thinner containing a large proportion of active slow solvent to the finish after the sanding operation. Its effect is to dissolve the top layer of dried lacquer and thereby cause it to flow out into the sandpaper scratches, building them up level with the rest of the surface.

Other features of Dr. Given's paper related to mechanical devices for rubbing and polishing, methods of buffing and masking, safety precautions in the use of lacquer such as ventilation and good housekeeping, and a statement of the shortcomings of lacquers.

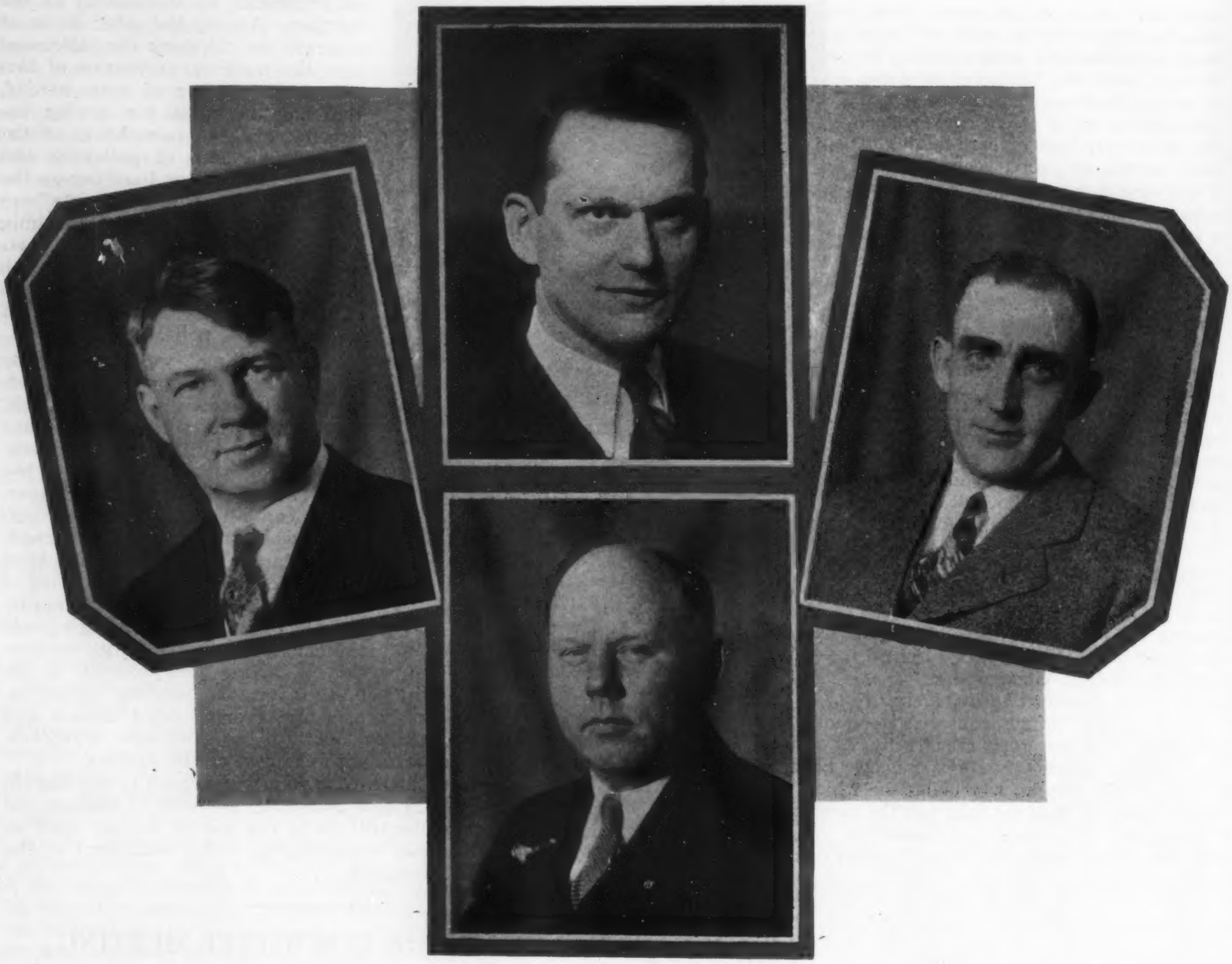
STANDARDS COMMITTEE MEETING

The regular meeting of the Standards Committee was held on Wednesday afternoon, Jan. 25, and was attended by 118 of the Committee and Society members and guests. Twenty-three reports were submitted by 10 Divisions of the Standards Committee, of which two were referred back to their respective Divisions for further consideration because of questions that were raised at the Standards Committee Meeting regarding them. Three subjects that were not included with those reports printed in the January issue of THE JOURNAL were among those approved. Inasmuch as they relate to subjects that are not of relatively great importance, and the recommendations embodied in them had been approved by the industries that are more directly interested in them, they were reported at the Standards Committee Meeting without prior publication in THE JOURNAL to dispose of them at this time.

H. T. Chandler, a member of the Iron and Steel Division, presented an interesting discussion of the use of the physical property charts and data for S.A.E. Steels and E. W. Upham, a member of the Lubricants Division, gave an interesting paper on the need for a definite, uniform system of identifying automobile lubricating oils and the use of the S.A.E. viscosity numbers for such oils. This paper was followed by considerable discussion, particularly by the oil company representatives, both for and against the use of this system of marking oil containers.

The detail account of the action taken by the Standards Committee on the reports of the several Divisions, together with the principal discussion thereon, is printed in this issue of THE JOURNAL commencing on p. 170.

The Production Conference Dinner Meeting on Thursday evening, Jan. 26, was attended by 20 members of the Society



MEMBERS PROMINENT AT THE STANDARDS COMMITTEE MEETING

H. T. Chandler (Upper Center), of the Vanadium Corporation of America, Who Discussed the Desirability of Revising the S. A. E. Steel Physical-Property Charts; E. W. Upham (Right), of the Chrysler Corporation, and H. C. Mougey (Left), of the General Motors Corporation Research Laboratories, Who Discussed the Importance of Car and Lubricating-Oil Manufacturers Specifying Suitable Oils by S.A.E. Viscosity Numbers; and A. J. Scaife (Bottom), of the White Co., Vice-Chairman of the Committee, Who Presided in the Absence of Karl L. Herrmann, of the Studebaker Corporation of America

and guests who are interested in developing the Society's production activities. President J. H. Hunt presided and very ably described what the Society has done and hopes to do along its lines of activities that will be of direct benefit to the production engineers and executives in the automotive industries. President-Elect W. G. Wall supplemented President Hunt's remarks and expressed his confidence that much can be done for the production engineers notwithstanding the fact that the time available to them for personal participation in Committee activities is usually more limited than that of the designing engineers. In the informal round-table discussion that followed, a number of pertinent suggestions were made that will be of value in developing the future activities of the Society in the work. It was apparent that those present felt that the result of the meeting was of an entirely constructive nature.

Operation and Maintenance Committee Meeting

The meeting of the members of the 1928 Operation and Maintenance Committee was held on Wednesday morning, Jan. 25, as scheduled, only four members being present, however. The work of the Committee during the last year and the various lines of activity that might more profitably be followed during the coming year were discussed in considerable detail and resulted in the assignment of several subjects to various members of the Committee for detail study. In general, it was planned that papers or reports dealing with these subjects that will be of direct interest to both motor-vehicle fleet-operating engineers and designing engineers, should be presented at the next Summer Meeting of the Society while those that relate more directly to the operating engineers would be presented at the next Annual Transportation Meeting of the Society.

INTERESTING INSTRUMENTS EXHIBITED

One of the most interesting features of the Annual Meeting was undoubtedly the exhibit of instruments for studying high-speed motion. Dr. C. Francis Jenkins discussed his slow-motion camera at the Research Session, motion pictures taken by Dr. Jenkins and R. W. Brown being shown.

R. W. Brown exhibited a six-element contact-type accelerometer which he had used in measuring riding-qualities. A description of this instrument is included in the

SOME OF THE EXHIBITS AT THE ANNUAL MEETING

The Stroborama (Center) Demonstrated by H. Billioque, of Musa-Hartzell-Ducasse, Inc.; the Vibroscope (Upper Left), Which Has Been Widely Adopted by Research Laboratories; the Instruments Developed by R. W. Brown (Upper Right) in His Study of Riding-Qualities Reported at the Research Session; the Three-Directional Graphs (Lower Right), Exhibited by H. H. Allen, of the Bureau of Standards, and Some of the Diesel Engine Equipment (Lower Left) That Was Demonstrated in the Italian Garden

news account of the Research Session at which Mr. Brown presented his paper on the subject mentioned.

The stroboscope and the Stroborama were also demonstrated, the latter in one of the more isolated rooms of the hotel, owing to the noise inherent in its operation. This instrument, which was demonstrated at the invitation of the Meetings Committee, proved of great interest to all of the members who observed it.

The general principle of the stroboscope is well known and there are probably very few research departments that do not employ it in one form or another. The Stroborama is such a radical development of the stroboscopic principle that it is not comparable with any of the generally-known types. Other stroboscopes must be used in semi-darkness on account of their limited illumination, whereas the Stroborama, employing a 1000-cp. light, may be used in daylight or under all ordinary shop conditions. No attempt is made to concentrate this light; on the contrary, it is diffused over a wide area so that it eliminates all shadows.

Practical Applications of the Stroborama

It was impossible to give more than a few examples of the practical applications of the instrument within the limits of a hotel room, but to all who watched the demonstrations the broad field for its use was immediately obvious.

First, a propeller was shown moving at a speed of 2200 r.p.m., the tips having a linear speed of 200 ft. per sec. Immediately the rays of light from the Stroborama were synchronized with the propeller, the blade was apparently halted and a small newspaper clipping pasted on the blade could be read easily. Next, as an example of an intricate mechanism, a magneto was run at 2000 r.p.m. and cam defects were easily perceived at this speed.

One of the most interesting demonstrations was that of a poppet-valve mechanism. The entire mechanism was clearly visible at one time, the action of the spring and the cam being seen simultaneously. The cam could be shown moving either slowly backward or forward and then held completely at rest with the valve on its seat; in this position the imperfections of the spring were clearly visible as the coils were surging as much as ¼ in. The mechanism could be observed from all different angles and positions and in clear relief. In actual practice, an entire engine could be observed and the action of all the valve springs compared.

A demonstration was made also showing a string about 5 ft. in length attached to a vibrating tuning-fork. As the tension was changed, the wave lengths altered and stood out clearly. A peculiarity of this test was that these waves did not merely move up and down, but when the string was viewed endwise, it was seen to have also a definite spiral motion.

The purpose of the tests was to show that means are available for actually seeing what takes place in any mechanism, regardless of its size, while it is in rapid motion and that observations can be carried on for as long a time as necessary and may be made by a considerable number of people at one time. On account of the diffused light, an entire chassis may be mounted on a testing block and the vibration at any point observed with the car operating at any speed.

Synchronizing Control Is Independent

One of the features of the Stroborama is that the synchronizing control is entirely independent of the object under observation. This has a great many advantages; the moving part may either be brought entirely to rest at any point in its cycle or it may be observed moving slowly backward or forward, similar to the effect of a slow-motion picture. Equally important, when a study is being made of a mechanism in which different elements are moving at different speeds, synchronization may be switched from one part to another in a moment's time.

The revolutionary feature of the Stroborama is that it has overcome the former limitations of regulating a strong current with a mechanical make-and-break mechanism. It has been this obstacle that has restricted other stroboscopes to the use of a small current and consequently a dim light. The powerful illuminating flashes of the Stroborama are of such short duration, about 0.000001 sec., that the moving object cannot move appreciably during that time and this accounts for the clearness obtained. There is also no limit to the speed which may be observed.

The instrument can be moved about easily and operates on a 60-cycle, single-phase, 110 or 220-volt alternating current.

The powerful illuminating flashes of the Stroborama are of hibited and demonstrated by H. Billioque and D. W. Hartzell, of Musa-Hartzell-Ducasse, Inc., New York City. Members who were unable to attend the demonstrations at the Annual Meeting should avail themselves of the first opportunity to see the instrument in operation, as only in that way can its real value to the automotive industry be appreciated.

RESEARCH PROJECTS MOVE FORWARD

Plans Made for Highways, Riding-Qualities, Fuels and Headlight Research

A thorough review of the research projects of the Society was made and plans for future progress were formulated at a series of meetings of the research subcommittees and main committee held during the week of the Annual Meeting. The Highways, Fuels, Headlighting and Riding-Qualities Subcommittees brought together, early in the week, a large attendance of members to discuss the subjects in these four provinces, and at the dinner meeting of the Research Committee, at which Dr. H. C. Dickinson, chairman, presided, presented reports for the consideration of that body.

B. B. Bachman, chairman, spoke for the Highways Committee, which acts in an advisory capacity to the representatives of the Society on the Cooperative Committee on Motor-Truck Impact Tests. These tests are being carried out under the sponsorship of the Bureau of Public Roads, the Rubber Association of America and this Society. He briefly reviewed the history of the Society's connection with the project and presented suggestions, made at the request of the Bureau of Public Roads, for modifications in the latest report on the test program, Progress Report No. 12, dated November, 1927. These suggestions were endorsed by the Research Committee.

The Fuels Subcommittee, which represents the Society in the Cooperative Fuel-Research being conducted jointly by it, the National Automobile Chamber of Commerce and the American Petroleum Institute, offered, through its Chairman, H. L. Horning, a tentative program for the continuance of this work. The Research Committee was asked to authorize the presentation of this program to the Cooperative Fuel-Research Steering Committee for approval and comment, and it granted this authorization. Included in the items suggested for future investigation were a survey of laboratory methods for the measurement of detonation, a continuation of the study of engine acceleration during the warming-up period and of volatility measurements, and a preliminary investigation into the fundamentals of the causes of detonation.

Lighting and Riding-Qualities Programs Endorsed

The Research Committee further endorsed the recommendations of the Headlight Subcommittee as to the future program for the headlight investigation that is being made at the Bureau of Standards under the technical direction of the Research Committee, with funds supplied by the National Automobile Chamber of Commerce, provided that it shall prove possible to continue this work. This tentative program calls for a continuation of the study of the

effect on visibility of variations in road and driving conditions both with and without opposing lights, of an increased range of light-source intensity of limits above 21 cp., and of various unsymmetrical headlight arrangements.

Endorsement was also granted to the view of the Riding-Qualities Subcommittee that it would be advisable to have carried out at the Bureau of Standards, with equipment already available, a study of the susceptibility of persons to vibrations of various amplitudes and frequencies. This was thought to be the next logical step in the riding-qualities program, since instrumentation has, by actual demonstration, advanced to the point where reliable measurements can be made and since such a fundamental study would be of value, not only to the entire automotive industry, but to other industries as well. The Research Committee was also of the opinion that the investigation suggested for the Bureau of Standards be coordinated with the riding-qualities study at Mason Laboratory, Yale University, preparations for which have been under way for several months, and that every possible assistance should be given in bringing this work to a successful conclusion.

Two topics for possible investigation were suggested and referred to the Research Department for action. The first, sponsored by V. P. Rumely, was a study of methods of finishing crankshafts, a subject of interest to all engine builders in the automotive industry. B. J. Lemon proposed the second topic, an investigation into the fundamentals of the relationship between wheel alignment and tire wear and of the principles governing wheel alignment and its measurement.

Annual Dinner Well Attended

Automotive Engineering's Past Reviewed and Future Presaged

A parti-colored sea of gas-filled balloons of varied hue floating over the dining tables greeted the eyes of more than 1000 S.A.E. members and guests when the doors of the grand ballroom of the Hotel Astor were thrown open for the Annual Dinner of the Society held on the evening of Jan. 12 in New York City. Inspiring pipe-organ music by Maurice Garabrant accompanied their entrance. Later, the Goodrich Silvertown Cord Orchestra, under the personal direction of Joseph Knecht, rendered pleasing selections; the silver-masked tenor sang very acceptably; Jules Brazil, affectionately known as Scotty, led oldtime songs; and motion pictures were shown of old Quebec, where the 1928 Semi-Annual Meeting is to be held, and of the inter-Section chassis-assembling contest that was staged at French Lick Springs last year. What happens when a radio announcer is on the air with only extremely vague ideas of what to say was demonstrated by Phillips Carlin, popular broadcaster for station WEAF, New York City.

Remarks of President J. H. Hunt

In the course of his remarks as chairman of the occasion, President J. H. Hunt reviewed briefly some of the achievements of the Society during the last year and commended the efficient work of the officers and of the permanent staff of the Society. He said that the Society is not only increasing in number of members but that both its financial condition and its technical standing are improving. The number of applications for foreign membership in the Society is increasing rapidly.

President Hunt mentioned the several successful National meetings that were held during 1927 and expressed appreciation of the assistance given the Society by Hon. E. P. Warner, Assistant Secretary of the Navy for Aeronautics. He said also that the fundamental basis of the success of the Society is the careful work done by the members of the Council. C. B. Whittelsey was mentioned as having held the record for consecutive service as member of the Council, a service that has now included 10 successive years.

A former year in the history of the automotive industry was said by President Hunt to have been designated as "the year of the reamer," a period during which the manufacturers were increasing piston displacement rapidly. He characterized the last year as having been the "year of the rumor," and went on to discuss briefly what its effect has been. He said that in his opinion the fact stands out that fundamental specifications are becoming more and more similar for the different makes of vehicle, a fact which indicates that the opportunity of the engineer, barring some new and unexpected development, will be in the field of refinement of designs already well established.

Previous to President Hunt's introduction of Toastmaster W. E. Wickenden, of the Society for the Promotion of Engineering Education, the entire assemblage arose and remained standing for several moments in silent tribute to the memory of Past-President Charles M. Manly.

Romantic Features of Engineering

Speaking of the miracle that automotive engineers have wrought, the motor-vehicle, Toastmaster Wickenden said that this achievement is a source of pride to the entire engineering fraternity; that the automotive engineer has taken the uncertain product of a quarter of a century ago and made of it a universal utility, one of the most reliable of our servants, the most economical of our larger tools, a product of grace and beauty, the world's marvel of cheapness, the world's symbol of luxury and the index of a man's place in the social scheme. This new instrument has been developed to be a perfectly flexible and adaptable hand wherewith to complete the great and powerful arm of our system of land transportation.

Notable as the romance of the technology of the automotive-engineering profession is, the speaker wondered if the engineer has not made even a greater contribution to the current philosophy of life. Ancient philosophies of life did not contemplate universal comfort as a very high level of spiritual or mental opportunity for all men. In an era of primitive agriculture and handcraft, the higher blessings were thought of necessarily as being reserved for the few. Men accepted slavery and serfdom as the inevitable elements of social economy, while in modern life technology, by enslaving the inanimate forces of nature, has made human slavery an anachronism.

Toastmaster Wickenden said also that the automotive engineer has taught the world that prosperity rests upon the full employment of labor; but he has written a new definition of thrift, not in terms of penuriousness, but in terms that enable men to thrive; and he has discovered that prosperity rests upon the uninterrupted and the ample purchasing power of the commonest folk.

Address of President-Elect W. G. Wall

The automotive industry faces a number of big problems as the year 1928 opens, said Mr. Wall, and many of these problems belong to the engineer. With the addition each year of several million motor-vehicles, it is necessary that thought be given to how we can best get them into operation on the roads. In trying to make motor-vehicles that will occupy less space, we must endeavor to compress the powerplants. Although we cannot make them much smaller, we can obtain considerably more power out of the present sizes of powerplant and reduce their weight. Better performance is needed and although opinions may differ as

to the best means of obtaining this, the trend at present is without doubt along the lines of higher compression, higher speed, lighter reciprocating parts, less friction, supercharging, and possibly toward two-cycle operation at constant compression. Chemistry is playing an important part in this work; and to accomplish these objectives stronger alloys of steel are needed, stronger aluminum alloys, better and more uniform fuels, more durable rubber fabrics, and lubricants which are less affected by heat.

After reviewing the facts, Mr. Wall remarked that it can be definitely said that there is no danger of a fuel shortage for combustion engines for the remainder of this century, although this does not mean that gasoline as now constituted will necessarily be used during all that period. It does mean that adequate variations of fuel such as blends and substitutes in sufficient quantity are available which can be used in the present engines.

The speaker outlined briefly the history of the Society and stated some of its problems, saying also that the entire membership of the Society, working cooperatively, is needed if the Society is to make any great headway. He mentioned the great importance of individual effort on the part of each member in regard to his own professional accomplishments as well as in reference to his attitude toward the Society. The remarkable development of the principles of motive power has accomplished the world's greatest achievements in transportation. Among other improvements, it has brought about an interchange of ideas between communities, a closer communion between men, and added greatly to the pleasure of living. He added that a very large part of this achievement has been due to the efforts of the members of the Society.

Engineering Leadership in Industrial Progress

Reviewing the history of the automotive industry since the year 1900 and taking a look forward for an equivalent period, J. Walter Drake, former Assistant Secretary of Commerce, remarked that in the year 1900 there was no such thing as defined automotive engineering. Starting with almost nothing, the automotive industry found it necessary to develop a practice of automotive engineering and a group of men who could administer it. That represented the beginning of the Society. Engineering in those days was done largely in the dark but those responsible for its future had a vision of world markets for motor-vehicles if they could be produced at a reasonable price, and engineers were called upon to accomplish this result. American automotive engineering was thus founded and it was the American automotive engineer who made mass production possible. But, to the speaker's mind, the greatest thing the automotive engineer has done for the benefit of American industry was to demonstrate, through the great force of cooperation, that is, mutual contact and the exchange of information, that the engineer can do for an industry something which that industry cannot do for itself in any other way. In Mr. Drake's belief, the Society has proved that in standardization lies the whole success of the industry. Standardization has been a vital contributing factor without which the industry never could have achieved what it has achieved.

Regarding the future and the mission of the engineer in the period in our economic life which we are now facing, Mr. Drake said that business men also have learned their lesson of cooperation. The most striking illustration of this is the existence of hundreds of trade associations which have united for a common purpose and through human contact, established a basis of sympathy and a common understanding, in the light of which they have attacked the problems of their industries and gone a long way toward solving them. The leadership of the engineer in the future will consist in a continual development of the cooperative spirit which has marked the whole course of progress of the Society and made the success of the automotive industry possible. Continued exertion of this kind is needed and the enlistment of the other groups of manufacturers and producers in an effort to lead them down the pathway of science on which, and only on which, lies the future success of this Country in its great industrial development.

In closing, Mr. Drake asserted that the whole problem of American industry must be taken as a National problem. The work being done by the Society cannot be isolated or segregated. It must be done in the full light and understanding of what other groups of men in the world of industrial endeavor are doing. The United States Government realizes that it has a real service to perform for American business. The men of science and the business men of America should utilize to the fullest extent the knowledge that the Government is really holding out a helping hand in its sincere desire to help them to do the things that must be done as these men think they should be done.

Present Trend in Passenger Travel

In discussing the present trend in passenger travel, Ralph Budd, president of the Great Northern Railway Co., said that we have become so accustomed to the ever-increasing commercial and industrial activity of the United States that our appraisal of business conditions at the end of a year as being good, fair or excellent, generally is based upon the increases in production compared with the increases in other years, and that it is a distinct shock to learn of a substantial decrease. Yet such a decrease has existed in the passenger traffic of the railroads since 1920, this decrease being approximately one-third, although, during the period from 1920 to 1927, the population of the United States increased approximately 13 per cent. He stated also that the loss of passenger traffic has been more severe on the Western railroads than on those in the East, doubtless because commutation travel in the vicinity of the large Eastern cities has been steadily increasing. In his opinion, the loss in railroad-passenger-business merely represents a change in mode of travel by the public.

Mr. Budd remarked that the private automobile is responsible for the fact that the railroad passenger-revenues were $250,000,000 less in 1927 than they were in 1920. The convenience of highway travel is responsible for the motorcoach which, in its best development, affords flexibility as to routes, schedules, and service, as well as riding comfort which is comparable with that of the automobile, and at a cost comparable with railroad fare. Seeing these advantages, many small operators began a few years ago to run motorcoaches, the result being that in many localities an excessive number of motorcoaches are operating on the highways, while the railroads, on tracks parallel with the highways, are continuing to maintain approximately their former schedules. As the public ultimately pays for all such transportation, it clearly is in the public interest to eliminate the wasteful duplication. In Mr. Budd's opinion, the ideal arrangement would be the substituting of correlated motorcoach and railroad-train schedules for the competing transportation services. He stated that the term "motorcoach," as used in his remarks, refers to the intercity type, which has a very distinct bearing on the passenger traffic of the steam railroads. It does not refer to the type of motorcoach used for city traffic, which is related to the passenger traffic of the street railways.

In some cases, he said, the best results can be obtained by having the railroads operate the motorcoaches as well as the trains. He considers effective regulation of the carriers of commerce on the highways, as well as of the railroads, a prerequisite to such an arrangement. Various States now have fairly complete motorcoach regulation within their borders, but the matter of Federal regulation is a live unsettled issue. The majority of motorcoach operators recognize the necessity for some Federal legislation to provide such regulation, but they question the extent to which Federal authority should supersede State authority. Intrastate commerce comprises such a large part of the total commerce carried by motorcoaches that their regulation should be left to the State authorities so far as possible, in Mr. Budd's opinion. Taxation and regulation should be separate functions. Taxation should be based on the pro-

portion the use of the motorcoach bears to the total use of the highways. Regulation should cover rates, schedules, safety for passengers, and such other factors as size, weight and speed of the vehicle, to assure proper use of the highways and protection for the other vehicles which use them.

Mr. Budd believes that the public will get the most for its money if all regulation of all carriers of commerce leaves the managers of the transportation agencies as free as possible in their operations. Individual initiative is so desirable that it should be encouraged, especially during the development period. Restrictions which prevent a substantial amount of experimenting will delay and may preclude ultimate possible attainment. Granting such treatment at the hands of regulatory bodies, the future of the motorcoach industry will be in large measure what the operators make it. Among the marks to aim for, the most important are greater travel-comfort for passengers and lower cost of operation.

In conclusion, Mr. Budd said that the trend is, and for several years has been, toward the highway for local travel, while long journeys continue to be made by railroad. The private automobile, and not the highway motorcoach, is the cause of this trend. Railroads may use motorcoaches to advantage in combination with rail trips and so hold some travel that otherwise would go entirely by automobile. Motorcoaches may also be used to take the place of unprofitable local-train service which without some substitute would have to be continued. The ultimate extent of highway motorcoach-development depends first upon whether the public will consider the service so important that it will adopt toward the industry a fair, reasonable, definite, and stable policy of regulation and taxation; second, upon how far motorcoach operators will go in providing the best equipment that can be devised and in maintaining schedules and other services that meet every need of local travel, including reasonably low fares.

Repeated-Stress Endurance of Metals

WHILE the old crystallization theory was still held, the supposed change in the nature of metals under repeated stress appeared analogous to the fatigue of muscles under repeated use; hence arose the term "fatigue of metals" to denote the phenomenon of failure under repeated stress. A better term would be "progressive failure," but the term "fatigue" still persists.

The modern viewpoint of fatigue failure pictures metal as yielding first at some point of localized weakness. There are many visible areas of localized weakness in metals, and probably many more areas so small as to be invisible. This first yielding of metal is considered to be a slipping action in which bonds between atoms are broken and then new and frequently stronger atomic bonds are formed. Along with this slipping action, and perhaps caused by it, there seem to develop actual fractures, breaking of atomic bonds with no formation of new bonds. These fractures start minute cracks in the metal, and at the ends of such minute cracks the stress concentration is very high. Under succeeding loadings, the cracks tend to spread like minute hacksaw-cuts until there is left insufficient sound metal to carry the load, and final fracture occurs suddenly.

If a part is subjected to a few cycles of stress above the endurance limit, fatigue-cracks start and will spread under subsequent cycles of stress much lower, perhaps 50 per cent, than the endurance-limit.

Basis of Study

In general, it may be stated that the study of fatigue phenomena in metals is a study of elastic straining and of spreading cracks, rather than of plastic straining. Both experience and theoretical consideration indicate that specimens for fatigue tests should be designed so as to have a well-defined critical section where failure will occur, and should be shaped so as to avoid sudden changes of cross-section in the vicinity of this critical section. The surface near this critical section should be polished and free from scratches. Special care should be taken to avoid notches, grooves and sharp shoulders near the critical section. The outstanding result of a series of fatigue tests is the determination of the endurance-limit, or fatigue-limit, of a metal; that is, the limiting stress below which the metal can withstand an indefinitely large number of cycles of stress without failure. Metals have withstood without failure 1,000,000,000 cycles of a stress just below the experimentally determined endurance-limit, and the same metals have failed after a few million cycles of stress slightly above this limit. For steel and iron it is rarely necessary to run tests beyond 5,000,000 cycles, and 50,000,000 cycles is nearly always sufficient for fatigue tests of any metal.

Using ordinary fatigue-testing machines, about 3,000,000 cycles of stress per day of 24 hr. is the maximum which can be applied to a specimen. Very slight changes in stress make large changes in the "life" of a specimen, and under a high "standard" stress a series of metals may be found to be arranged in an order of merit quite different from the order given by a series of tests under a lower "standard" stress. Test data from several laboratories show no marked effect of speed of testing on endurance-limit for a range from 200 cycles per min. to 5000 cycles per min. The small amount of test data available shows no effect on endurance-limit of periods of rest during the progress of a fatigue test.

Effect of Heat-Treatment

The effectiveness of heat-treating decreases markedly with increase in cross-section of the piece to be heat-treated. While the use of alloying elements, nickel, chromium, molybdenum, vanadium, and the like, increases the effectiveness of heat-treatment, especially for large specimens, yet even with alloy steels, and much more with plain carbon-steels, both the tensile-strength and the fatigue of a piece, say 1½ in. in diameter, is markedly less than the same properties of a piece about the size of a test-specimen, say ½ in. in diameter, even when the chemical composition and the temperatures used in heat-treatment are the same. Moreover, as size of piece increases, the internal strains set up by heat-treating tend to increase. A factor of safety based on the endurance-limit is just as necessary for parts subjected to repeated stress as is a factor of safety based on tensile-strength or elastic-strength for parts subjected to static loading. Notwithstanding the inference of the usual formulas, materials are not truly homogeneous nor truly isotropic.

Relation of Physical Properties

The endurance-limit seems to be more closely correlated with the tensile-strength of a metal than with any other property determined in an ordinary tension-test. Endurance-limit seems to be fairly well correlated with Brinell hardness but seems to have very little relation to elastic-limit or yield-point. This latter fact is not surprising when it is remembered that the elastic-limit or the yield-point marks the beginning of appreciable slipping action over a considerable volume of metal, while fatigue failure consists in the spreading of a crack from some one region of high stress. Endurance-limit seems to bear no relation

to ductility nor to the results obtained by impact tests on notched specimens.

For rolled or forged steel and iron the endurance-limit under reversed flexure is usually between 45 and 55 per cent of the tensile-strength, averaging about 50 per cent. For steel castings this endurance ratio is somewhat lower, about 40 per cent. For cast iron it is still lower, about 33 per cent. For non-ferrous metals the endurance ratio varies over a wide range, from less than 25 per cent for cold-drawn copper and certain aluminum-copper alloys to 50 per cent for annealed bronze.

For rolled or forged steel, up to a Brinell hardness number of about 400, the endurance-limit under reversed flexure is about 250 times the Brinell number. This ratio does not apply to other metals.

In designing machine parts which are to be subjected to repetitions of direct tension and compression it must be borne in mind that in nearly all machine parts appreciable flexural stresses will be set up, and that it is not safe to neglect them. Under cycles of reversed torsion the endurance-limit of metals ranges from 40 to 70 per cent of the endurance-limit under cycles of reversed flexure, the average being about 54 per cent.

In general, the criterion for strength of metal parts subjected to cycles of one-way stress is the elastic-limit or the yield-point rather than the endurance-limit. In no case should the strength of a metal be regarded as higher than the stress which will cause elastic failure. In general, whichever is lower, elastic-limit or endurance-limit, is the criterion of strength for a metal part.

Collateral Facts

Under high temperatures the tendency of metal to "creep," slowly stretch or compress, under steady load becomes increasingly important as temperature rises, while fatigue-strength becomes less and less important. The test data available at present indicate that under high temperatures the fatigue-strength of metal will not be reduced by any greater percentage than will the tensile-strength. Under temperatures up to 500 or 600 deg. fahr., a few metals have shown under test a slight increase of fatigue-strength over that developed at ordinary room temperatures. Alloy steels and tempered carbon-steels show a falling off of fatigue-strength for all temperatures above ordinary room temperature.

The weakening effect of corrosion may amount to as much as 15 per cent.

The test data available do not indicate that there is any chemical ingredient or alloying element which gives directly to steel outstanding fatigue-strength. Certain alloying elements, nickel, chromium, vanadium, molybdenum, manganese, and silicon among them, do, however, have a marked indirect beneficial effect on the static-strength and the fatigue-strength of steel. Alloying elements lessen the rate at which the crystalline changes in steel take place and thus widen the tolerances of time and temperature for heat-treating and increase the size of piece which can be "penetrated" by heat-treatment.

Effective heat-treatment is remarkably potent in increasing both static-strength and fatigue-strength of steel. However, it must always be borne in mind that the results obtained on small pieces under laboratory conditions cannot be duplicated on large pieces under shop conditions. Attention is called to the Brinell hardness-test as a nondestructive test, applicable to many finished parts, which furnishes a fairly reliable index of the fatigue-strength of rolled and forged steel parts.

For all chemical compositions and heat-treatments of wrought ferrous metals, below a Brinell hardness of 400, the endurance ratio, endurance-limit to tensile-strength, varies but little.

Commercial cold-rolling or cold-drawing of metals increases greatly their elastic strength, and increases the tensile-strength to a less degree. The fatigue-strength of steel is increased by cold-working in about the same proportion as is the tensile-strength. For non-ferrous metals the percentage of increase of fatigue-strength due to cold-working is usually less than the percentage of increase in tensile-strength. The fatigue-strength of some cold-worked non-ferrous metals can be markedly increased by heating them to a temperature well below the critical range for the metal. This gentle heating is supposed to relieve internal strains in the metal.

A small hole in a machine or a structural part under tension, compression or flexure sets up localized stress at the edge of the hole. By the formulas of the theory of elasticity the stress-concentration factor can be computed. For holes less than one-sixth the width of the piece the theoretical stress-concentration factor is about 3. For a small radial hole in a shaft under torsion the theoretical stress-concentration factor is 4.

Threads, Shoulders and Fillets

At the root of a U. S. Standard screw-thread, as shown in the standard drawings, is a sharp corner. This means a theoretical stress-concentration factor of infinity. Of course in any actual thread the corner is not sharp, the die or the lathe tool which cuts the thread being rounded-off. The British standard or Whitworth thread is laid out with a thread angle of 55 deg., a definite radius, r, at the bottom of thread, and a ratio of diameter at bottom of thread to r of about 4.4.

Experience with U. S. Standard threads on the bolts of a repeated-stress testing machine at the University of Illinois indicates an effective stress-concentration factor of about 4 for bolts subjected to repeated direct-tension. Experiments by R. R. Moore indicate a much lower effective stress-concentration factor for screw-threads subjected to reversed flexure. From the data available and the theoretical stress-concentration factor for Whitworth threads it is recommended that for U. S. Standard threads subjected to repeated stress the stress-concentration factor be taken as 4; and again the designer is cautioned that the consideration of stress concentration does not obviate the necessity for using a factor of safety in design.

A curious fact, somewhat difficult of explanation, has been brought out by R. R. Moore. The injurious effect of a single circumferential groove is much greater than that of a screw-thread of several turns cut with the same tool which formed the groove. In the case of bolts in which the screw-thread is nearly covered up by the piece into which it is screwed, or by nuts, there would be left to resist external forces only one or two threads, and the conditions would approach those in R. R. Moore's tests with a single groove. A length of thread beyond that required for fastening the bolt adds distinctly to the strength of a bolt subjected to repeated stress. Tie-rods in airplanes are subjected to vibration, and hence to a certain range of repeated stress. When fatigue failures occur, they are usually at sharp shoulders or at screw-heads. Bolts and screws under repeated stress show occasional fatigue-failures starting at the roots of threads. "Live," rotating, axles under transverse load are subjected to cycles of reversed bending and occasionally fail, practically always near the fillet at a shoulder. On some railways periodical inspection of axles for incipient cracks has reduced axle failures in service almost to the vanishing-point.

Shafts for transmitting power are subjected to repeated torsion and frequently to reversed bending as well. Fatigue failures in shafts commonly start at the root of a keyway, where there is a high concentration of torsional stress. Fatigue failures in crankshafts sometimes occur at the junction of shaft and crank-arm. Piston-rods sometimes develop fatigue failures in service, the fracture usually starting at the root of a thread or at a sharp shoulder. Springs are designed to absorb the energy of repeated loading. Flat springs occasionally fail under repeated flexure, the fracture usually occurring at the point of bearing of one leaf on another. Coil springs occasionally fail under repeated axial-load, which sets up torsional

stresses in the coils. Valve-springs in internal-combustion engines, working under high temperatures, are especially liable to fatigue failure. Airplane propellers occasionally develop fatigue failures. They are subjected to a wide range of complex stresses, including torsional stresses. Propellers made of wood are subjected to repeated shearing stresses along the grain of the wood.

Welded Joints

Welded joints, especially electric-arc and oxyacetylene welds as ordinarily made, are distinctly weak in resistance to repeated stress. Although better results are expected from some of the newer processes of welding, available test data indicate that from the general run of fusion-welded joints a fatigue-strength of 50 per cent of that of the plate metal is about all that can be regarded as available.

Locating Cracks

Fatigue cracks can be detected by direct examination of the surface of the suspected piece or by the use of a small magnifying glass. If a steel part is washed with kerosene in which is suspended iron "mud" from grinding discs, and the piece is then magnetized, the locations of cracks will be shown by the gathering of minute iron particles.[1]

If the surface of a machine part is rubbed with oil, the oil wiped off, the surface then coated with a thin paste of whiting, and the part then mounted on blocks and struck smartly so as to set up bending-stresses, the location of a crack will be shown by the oil stain on the whiting. When the oil is wiped off the surface, some remains in any small cracks, and the bending stresses squeeze it out, discoloring the whiting.

In service, structural and machine parts are subjected to very many cycles of working-stress and to occasional cycles of overstress. The occasional cycles of overstress, if above the endurance-limit, may be considered as starting fatigue-cracks. During the first few thousand cycles of stress these cracks usually cannot be detected by any means now available; they are so small that the static-strength properties of the material are not appreciably affected. However, there are no data which indicate that such minute cracks once started are "healed" by periods of rest; on the other hand, once such cracks are started they will spread under cycles of stress well below the original endurance-limit of the metal. Test data on this point are very few, but recent tests at the University of Illinois on car-axle steel indicate that, if fatigue cracks are once started, they will spread under cycles of stress as low as 65 per cent of the original endurance-limit.

Very little can be said as to the length of time or the number of cycles of stress necessary to cause failure of a machine part. If subjected to stresses beyond the endurance-limit, two specimens from the same bar of metal, tested under as nearly identical conditions as can be secured in the laboratory, will show wide variation in "life." The critical stress below which progressive fracture will not occur is fairly well defined for all, or very nearly all, commercial metals; the length of "life" of a part repeatedly stressed beyond the endurance-limit is not at all well defined.—From the Manual, by H. F. Moore, issued by Engineering Foundation.

[1] Method devised by Dr. Rawdon, of the Bureau of Standards.

Applicants for Membership

The applications for membership received between Dec. 15, 1927, and Jan. 16, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ARMOUR & Co., Union Stock Yards, *Chicago*.

ATLAS DROP FORGE Co., *Lansing, Mich.*

AUSTIN, SIR HERBERT K. B. E., chairman of board of directors, Austin Motor Co., Ltd., *Birmingham, England*.

BALASHOFF, NICHOLAS V., aeronautical engineer, Bellanca Aircraft Corporation, *Mariner's Harbor, Staten Island, N. Y.*

BARNER, LIEUT. JAMES DUKE, U. S. N., Naval Air Station, *Hampton Roads, Va.*

BAZATA, JOSEPH F., engineer, spark-plug division, MotoMeter Co., Inc., *Long Island City, N. Y.*

BEELAT, WILLIAM C., assistant supervisor of patterns, Continental Motors Corporation, *Detroit*.

BELL, CHARLES ARTHUR, engineering representative in production, Studebaker Corporation of America, *South Bend, Ind.*

BELTZ, HAROLD H., inspection, Motor Wheel Corporation, *Lansing, Mich.*

BENDER, CHARLES J., president, Ahlberg Bearing Co., *Chicago*.

BERRY, WALLACE STOTT, automotive service engineer, J. G. Brill Co., *Philadelphia*.

BILLIOQUE, HENRY, chief engineer, Musa-Hartzell-Ducasse, Inc., *New York City*.

BINYON, ALGERNON HAMO, Laneside, Kingshighway, *Westport, Conn.*

BONAR, CHARLES L., chassis layout, Hupp Motor Car Corporation, *Detroit*.

BOYDEN, REAGH G., mechanical superintendent, Boston & Maine Transportation Co., *East Cambridge, Mass.*

BOYER, HAROLD B., draftsman, American Car & Foundry Motors Co., *Detroit*.

BOYSEN, WILLIAM R., sales engineer, Hyatt Roller Bearing Co., *Detroit*.

BURDICK, WILLIAM BEDELL, president and owner, Ossining Motors Corporation, *Ossining, N. Y.*

BURKE, WILLIAM H., superintendent, Kermath Mfg. Co., *Detroit*.

BUYSSE, RICHARD L., engineer, motor equipment division, Michigan Bell Telephone Co., *Detroit*.

CAMPBELL, E. EARL, experimental engineer, Chrysler Corporation, *Detroit*.

CARLSON, ALEXANDER, vice-president and general manager, Dietrich, Inc., *Detroit*.

CARNIE, JOHN, chassis layout draftsman, American Car & Foundry Motors Co., *Detroit*.

CHESLEY, WILLOUGHBY S., JR., automotive engineer, Tide Water Oil Co., *New York City*.

CLEMENTS, HUBERT I., automobile engineer, H. I. Clements, Rushcutter's Bay, *Sydney, New South Wales, Australia*.

COCHRANE, WALTER S., mechanical engineer, Chrysler Corporation, *Detroit*.

CONNOR, JOHN H., factory representative, Robert Bosch Magneto Co., *Long Island City, N. Y.*

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WHATMOUGH, WILFRED AMBROSE, managing director, Autostat, Ltd., *London, England.*
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Applicants Qualified

The following applicants have qualified for admission to the Society between Dec. 10 and Jan. 10, 1927. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

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